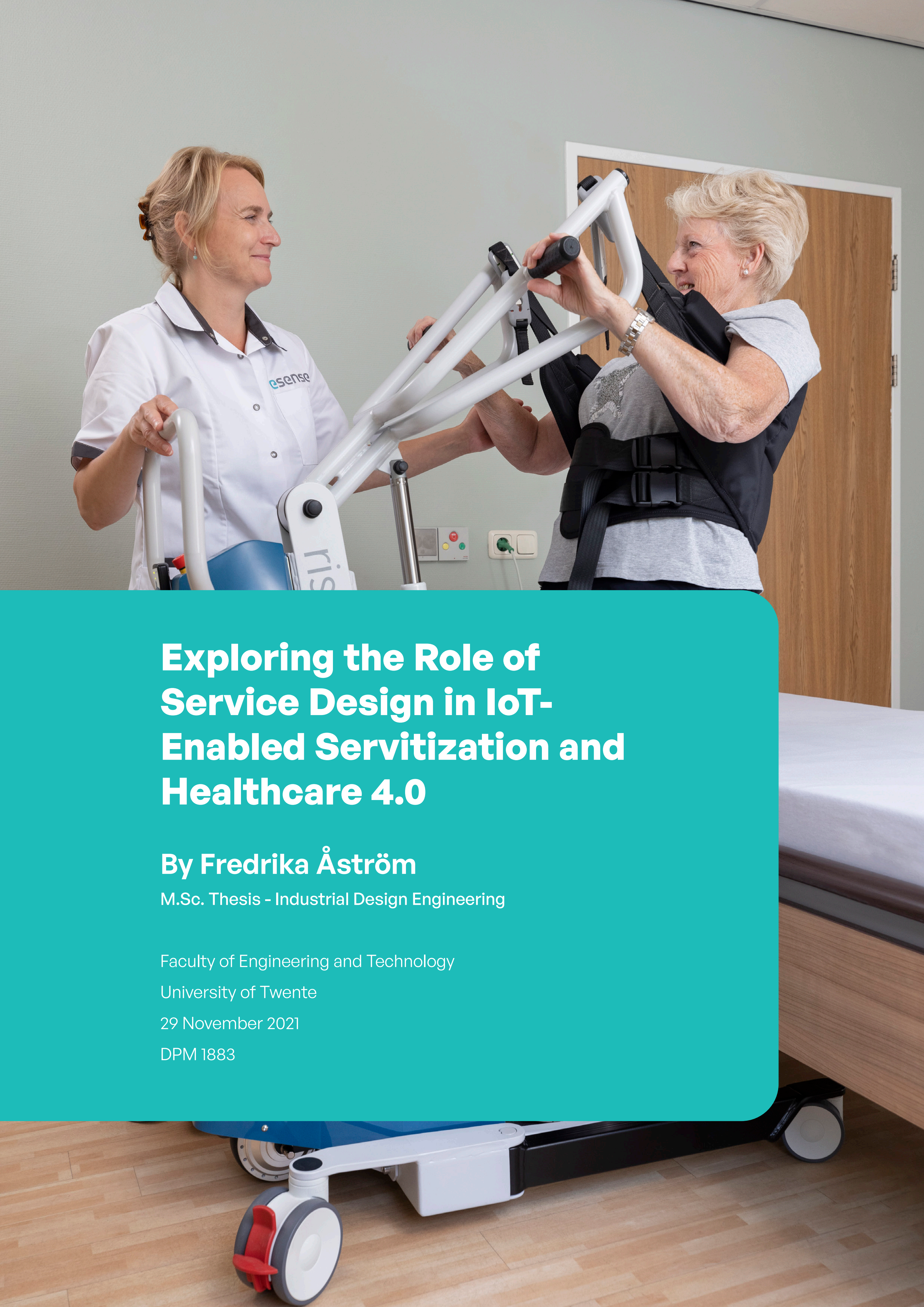

Exploring the Role of Service Design in IoT-Enabled Servitization and Healthcare 4.0

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Abstract

In the emerging ‘Industry 4.0’ and ‘Healthcare 4.0’ paradigms, healthcare technology manufacturers can benefit from exploring IoT-enabled servitization as a means to gain a competitive advantage, create new revenue streams and strengthen customer relationships. However, to achieve successful service innovation in healthcare, companies must obtain a deep understanding of customer needs, and the context for which they are designing. Service design is seen as a human-centered approach to service innovation, that may be especially relevant to designing for healthcare. However, at the time of this thesis, few practice-based studies had been carried out to explore service design’s role in IoT-enabled servitization for Healthcare 4.0. This research aimed to bridge this gap, by deploying a Research Through Design (RTD) approach, to a case provided by the healthcare device manufacturer *esense*. In this research, service design tools and methods were deployed to involve key stakeholders in the research process of a novel Product-Service System (PSS) proposal, anchored in customer insights. It was found that service design was an effective approach to help manufacturers switch from a product-oriented perspective, towards a customer-centric one. This research provides an example of how service design can be implemented by manufacturing companies who are taking their first steps towards IoT-enabled servitization.

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Abbreviations

B2B	Business to Business
B2C	Business to Consumer
BM	Business Model
HWaaS	Healthy Working as a Service
IoT	Internet of Things
PBDR	Practice-Based Design Research
PSS	Product-Service System
SaaS	Software as a Service
ROI	Return on Investment
RTD	Research Through Design
UX	User Experience

1. Introduction

1.1 Research Context

The service economy has seen rapid growth in the last decades, contributing to 64% of the global GPD in 2019 (World Bank, 2019). In this new service-oriented marketplace, firms must re-evaluate how they can capture and co-create value with their customers (Teece, 2010). Therefore, manufacturers are increasingly exploring servitization – the strategic switch from selling products to selling Product-Service Systems (PSS) – to generate new value for customers and increase competitiveness (Baines et al., 2009).

The development of Internet of Things (IoT) has helped to accelerate servitization in manufacturing and healthcare (Aceto et al., 2020; Naik et al., 2020; Suppatvech et al., 2019), contributing to the 'Industry 4.0' paradigm, its sibling 'Healthcare 4.0' (Aceto et al., 2020), and the service economy (Blomberg & Stucky, 2017). IoT can be described as a network of connected entities (e.g. 'smart products') that, through the presence of sensors, can be identified, located and acted upon (Ng & Wakenshaw, 2016). Healthcare technology manufacturers can leverage IoT to stay ahead of the market (Reedy, 2019). However, healthcare is a complex context to design for, and can often be resistant to technological innovation (Plsek, 2003; Rodrigues & Vink, 2016). This calls for manufacturers to increase stakeholder involvement during service innovation activities for the healthcare sector (Bronsoler, 2020).

Successful service innovation and adoption relies on a keen understanding of customer needs (Den Hertog et al., 2010). The emerging field of Service Design can be of value for this purpose, supporting the servitization in manufacturing (Bhamra et al., 2017; Costa et al., 2017; Solem et al., 2021) and healthcare (Robert & Macdonald, 2017). service design is increasingly seen as a human-centered approach to service innovation (Clatworthy, 2017; Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017; Stickdorn et al., 2011), making use of a designer's tools, methods, and approach to problem-solving (Sangiorgi & Junginger, 2015). In its human-centeredness, service design investigates the needs of customers and key stakeholders, and often invites these actors to participate in the design process (Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017).

Despite manufacturing's and healthcare's growing interest in IoT (Aceto et al., 2020; Uchihira et al., 2016), as well as service design (Clack & Ellison, 2019; Robert

& Macdonald, 2017), at the time of writing this thesis, few studies had been done on the implementation of service design to create IoT-enabled PSS for healthcare technology manufacturers. Most studies on servitization for the manufacturing industry are done by researchers reporting on the mistakes and successes of existing companies' endeavors, rather than participating in the design process, calling for more practice-based research to shape the discourse in the field (Baines et al., 2009). Thus, this project attempts to bridge this gap, by conducting Practice-Based Design Research (PBDR), to generate knowledge through the design of an IoT-enabled PSS for the healthcare technology brand esense.

1.2 The Case: Healthy Working as a Service

This project deploys a PBDR approach to design an IoT-enabled PSS with the healthcare technology brand esense. Esense aims to provide 'the ideal solution to move heavy mobile care products' . Their portfolio consists of patient lifts (e.g. Figure 1), an electric drive assist system with sensors that can be built into mobile equipment, as well as an ergonomic measurement tool called the ergometer. At the beginning of this project, esense had successfully built in IoT modules into their patient lifts, to collect data regarding usage and system status. This implementation provided the platform for a potential IoT-enabled PSS to be built. Therefore, this research studied how the built-in IoT-collection could be used to co-create value with their customers in a PSS offering. This project was referred to internally as 'Healthy Working as a Service' (HWaaS).

The starting vision for the project was to use IoT-collected data from the patient lifts, to improve the way in which caregivers use their tools. This vision stemmed from the troubling observation that caregivers endure the highest sickness absence in the Netherlands (Health Council of the Netherlands, 2012), and often suffer from musculoskeletal diseases (Andersen, 2020; van der Molen et al., 2018). Pushing and pulling heavy loads is considered one of the main contributors to physical complaints in healthcare, such as shoulder and neck problems (van der Molen et al., 2018). Although devices exist to reduce physical load (e.g. patient lifts), caregivers must know how to use them correctly to avoid injury (Andersen, 2020). Therefore, esense is committed to help healthcare professionals acquire healthy working habits and movements with the patient lifts (Working Healthy with Esense, n.d.).

IoT allows information to flow to and from the product remotely (Javaid & Khan, 2021). With the built-in IoT modules, esense can track how the products are being used wirelessly, and unobtrusively. Moreover, IoT can help facilitate servitized-business models (BMs) for manufacturers (Suppatvech et al., 2019). However, firms pursuing a service innovation need to test and validate their hypotheses in the target market (Teece, 2010; Vargo & Lusch, 2004), and design a viable BM (Teece, 2010). An increasingly common method for business innovation is the Lean Start-Up approach (Maurya, 2012), which has high relevance in the development of services as well (Ojasalo & Ojasalo, 2015). Therefore, parts of the Lean approach were adopted in this thesis, with the support and guidance from Wordlenig - an innovation consulting firm that helps organizations capitalize on new technologies and market opportunities (Wordlenig - Innovatie, n.d.), partnering with esense for the HWaaS project. Together with Wordlenig, iterative market experiments were carried out and integrated into the service design process.

Figure 1. Picture of the passive patient lift (esense line+) being used in action.

In summary, this project conducts a service design process for service innovation, supported by a Lean approach, to craft an IoT-enabled PSS for esense. By applying a Research Through Design approach (RTD), the learnings from this project can inform the discourse on service design's role in IoT-enabled servitization for healthcare 4.0. Important to note are the special circumstances under which this project was conducted, namely, the COVID-19 pandemic of 2020 and 2021. The spread of the COVID-19 pandemic placed additional strain on the healthcare system (Data Europe, 2020), and forced society into a rapid digital transformation (Iivari et al., 2020). In these circumstances, service designers needed to find ways to engage stakeholders in the design process, in an online, or hybrid, environment, which lead to additional recommendations for research and practice.

1.3 Research Questions

This research project aimed to investigate the role of service design in IoT-enabled servitization for the healthcare technology context, guided by the main research question:

> **MRQ: How can service design be implemented to help healthcare technology manufacturers deploy IoT-enabled servitization?**

The main research-question was supported by a number of sub-research questions:

> **SRQ1:** What is the role of service design for manufacturing firms exploring servitization?
>
> **SRQ2:** What is the role of Industry 4.0 technologies (i.e. IoT) for manufacturers exploring servitization in the healthcare context?
>
> **SRQ3:** What recommendations exist regarding the types of IoT-enabled servitized BMs that manufacturers can deploy?
>
> **SRQ4:** What challenges do manufacturers face when innovating for Healthcare 4.0, and how can they overcome them?
>
> **SRQ5:** How can knowledge from the Lean approach be integrated into the service design research process, to support IoT-enabled servitization?

These research questions were answered by: (1) carrying out a literature review, and (2) carrying out PBDR and applying an RTD approach onto the esense HWaaS case. The insights from these design activities played a formative role in generating knowledge (Stappers & Giaccardi, 2017), which in turn informed the main research question. The case-specific research question reads as follows::

> **Case RQ: How can service design be leveraged to create an IoT-enabled Servitized BM for esense, which allows healthcare organizations to promote caregiver health during patient transfer?**

The case-specific research question was used to guide the RTD activities undertaken for the HWaaS case (see Part D of this report).

1.4 Esense & Indes BV

Esense is a healthcare technology brand, owned by Indes BV - a product design and development company focusing on products for healthcare and mobility, located in Enschede, the Netherlands (About Indes, 2021). Indes strives to help make the working environment healthier and safer, and enhance individuals' possibilities. Moreover, focusing on the end user and understanding their needs and challenges is a core part of the business' product development activities. Esense, as a sub-brand of Indes, focuses on heavy mobile equipment, mainly used in the healthcare sector, and strives to 'change heavy to healthy' by utilizing electric drive (e-drive) support to boost movement. The esense product line consists of patient lifts, e-driven kits that can be built into other mobile equipment, and the ergometer that can be mounted on devices to measures the pushing and pulling forces exerted. Moreover, the esense products have integrated smart sensor systems that translate push and pull forces of the user into a smooth e-driven boost, which reduces the physical load needed to move equipment (Esense, n.d.-a).

1.5 Wordlenig

Wordlenig is an innovation studio and design agency that helps companies successfully capitalize on market opportunities (Wordlenig - Innovatie, n.d.). They do so by conducting market research and validation for external clients, to help them understand and market demands. In this way, Wordlenig helps their clients build sustainable business proposals, which are driven by a market-pull, rather then investor capital. Wordlenig has a continuing, fruitful collaboration together with Indes, as well as other clients (Wordlenig - Innovatie, n.d.). In this project, Wordlenig functioned as mentor and innovation partner, guiding the student researcher, as well as co-facilitating various research activities and market experimentation.

1.6 Chapter Overview

Chapter 1 In the first chapter (this chapter), the reader is introduced to the research projected conducted in this Master Thesis project.

Part A. Background

Chapter 2 The second chapter helps shape the background research conducted in this project, and contains a literature review on the topic of service design.

Chapter 3 The third chapter contains a literature review on the topic of IoT-enabled servitization in Industry 4.0 and Healthcare 4.0.

Part B. Domain Knowledge

Chapter 4 In the fourth chapter, the domain-specific knowledge necessary for the HWaaS case is detailed.

Part C. Methodology

Chapter 5 The fifth chapter introduces the research methodology and process deployed in this project.

Part D. Design Research for HWaaS

Chapter 6 In the sixth chapter, the 'Discover' phase of the service design process is discussed.

Chapter 7 In the seventh chapter, the 'Define' phase of the service design process is explained.

Chapter 8 The eight chapter describes the 'Ideate' phase of the service design process.

Chapter 9 In the ninth chapter, the 'Validate' phase of the service design process is discussed.

Chapter 10 The tenth chapter presentes the final PSS concept, as well as recommendations for subsequent pilot tests.

Part E. Discussion & Conclusion

Chapter 11 In the eleventh chapter, the research findings are discussed.

Chapter 12 The twelfth chapter concludes the thesis.

Part A. Background

2. Service Design

The field of service design can support manufacturing companies transitioning towards smart PSS offerings (Costa et al., 2017; Solem et al., 2021). Service design is increasingly recognized as a human-centered approach to service innovation (Clatworthy, 2017; Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017; Stickdorn et al., 2011; Torres & Miranda, 2020). In this chapter, a review of service design literature is conducted. First, key definitions are given of the concept of 'Service' (2.1), as well as service design (2.2). In 2.3, the process of conducting service design in practice is described, followed by a discussion of common tools leveraged in the field (2.4).

2.1 What is a Service?

The understanding of a *Service* has evolved in the last decades (Sangiorgi & Prendiville, 2017), alongside the development of the marketing perspective on 'Goods' and 'Services'. During the nineteenth century, and large parts of the twentieth century, economic models considered the sale of 'Goods' as the main unit of exchange, illustrating a Goods-Dominant (G-D) Logic (Vargo & Lusch, 2004). However, at the end of the twentieth century, a new marketing perspective emerged: Service-Dominant (S-D) Logic. This perspective was presented by Vargo and Lusch in their seminal paper from 2004, which permeated scientific literature and became "probably the most relevant development in modern marketing thought" (Tregua et al., 2021, p. 563), and a catalyst for further discussion (Saarijärvi et al., 2017). Thus, S-D logic has been highly influential in informing the modern view of service provision, and will therefore be adopted throughout this research project[1].

S-D logic describes a recalibration of the marketing perspective, suggesting a new relationship between goods and service, where goods are means to provide a service (Lusch & Vargo, 2006; Vargo & Lusch, 2004). It shifts the focus from

[1] **The difference betwee S-D Logic & Service Logic:** There exists some friction between two main schools of thought on service science (Saarijärvi et al., 2017), being Service Logic (e.g. Grönroos, 2006) and S-D Logic (e.g. Vargo & Lusch, 2004). Despite there existing some differences between these concepts, they also share many similarities, as identified by Saarijärvi et al., (2017). This project opts to use the phrase S-D Logic to refer to both contemporary literature on S-DLogic and Service Logic.

tangible goods, towards a focus on intangible resources, processes of exchange and relationships between stakeholders. Moreover, S-D logic builds upon the notion that resources are not valuable in and of themselves, but rather become valuable when humans derive value from them (Vargo & Lusch, 2004). Thus, value is always co-created with the customer, meaning that companies can only provide a value proposition, not the value itself (Lusch & Vargo, 2006). This perspective is customer-centric, (as opposed to producer-centric), and demands continuous learning from, and collaboration with, customers to adapt to their needs (Vargo & Lusch, 2004).

The traditional perspective on services was rather limited: services were seen as what tangible goods are not (Vargo & Lusch, 2004). Early on, services were often defined using the IHIP model, being that services were Intangible, Heterogeneous, Inseparable, and Perishable (Zeithaml et al., 1985). However, this model became increasingly questioned for its inability to represent all kinds of services (Lovelock & Gummesson, 2004), the development of new technology (Moeller, 2010), and the increasing similarity between products and services in modern organizations (Sangiorgi & Prendiville, 2017). Under S-D Logic, a service is viewed as the process of applying competences and resources to co-create value with the customer, other entities, or the entity itself (Vargo & Lusch, 2004). Value is often described as experiential and contextual (Wetter-Edman et al., 2014). In S-D Logic, a service provider cannot create value for the customer, but only create a value proposition (Sandström et al., 2008; Vargo & Lusch, 2004). Sandström et al. (2008) classify the service value propositions in two dimensions: the Functional Value Proposition, and the Emotional Value Proposition. The value proposition is made possible by the Physical/Technical Enablers, including the technologies that provide a system for which a service can take place (Sandström et al., 2008).

Despite the growing attention around services, there exists no consensus on its exact definition (Spohrer et al., 2007), identifying a surprising gap in the body of scientific literature that bases its activities around this term (Moeller, 2010). Therefore, in pursuit of a working definition for the term ‘service’ in this research project, literature on the topic was reviewed, with the findings summarized in Table 1. Based on the literature review, a definition of service was created, as shown on the next page.

Table 1. Summary of contemporary definitions of 'Service' from service literature, including a S-D Logic and Service Logic perspective.

Source	Definition
Vargo & Lusch (2004, p. 2)	"...as the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself."
Grönroos (2006, p. 223)	"... a process where a set of resources interact with each other and with the customer aiming at supporting the customer's processes in a value-generating way."
Wetter-Edman et al. (2014, p. 106)	"... a perspective on value creation where value is co-created by customers and other actors and is assessed on the basis of value-in-use in relation to the involved actors' intentions."
Holmlid et al. (2017, p. 98)	"... actors that integrate resources to systematically create values and outcome"

Definition of *Service*

Service is the process of applying resources (e.g. knowledge, skills) to co-create value with stakeholders, where the value is assessed by the beneficiary, according to the derived value-in-use.

2.2 What is Service Design?

Service design and design thinking are two human-centered concepts that often overlap (Sangiorgi & Prendiville, 2017), and exist in a novel field of design where the vocabulary is still developing (Torres & Miranda, 2020). Although there is an implicit understanding that design thinking plays a role in service design (e.g. Clack & Ellison, 2019; Clatworthy, 2017; Stickdorn et al., 2011; Yu & Sangiorgi, 2014), and that service design can be seen as the application of design thinking in the domain of designing new services (Clatworthy, 2017; Torres & Miranda, 2020), the relationship between the two has been insufficiently researched (Torres & Miranda, 2020). Therefore, both concepts are discussed in this chapter, to create a foundational understanding of the field of service design.

2.2.1 Design Thinking

Throughout service design literature, it is implicitly understood that 'Design Thinking' plays a key role in the design for services, sometimes referred to as 'service design thinking' (e.g. Clack & Ellison, 2019; Clatworthy, 2017; Stickdorn et al., 2011; Yu & Sangiorgi, 2014). Design thinking is the strategic way in which designers approach complex, open-ended problem-solving, through iterations of creating, testing, and evaluating different proposals (Dorst, 2010). Organisations are increasingly interested to embed these skills into their daily operations and mind-set of staff (Dorst, 2010; Sangiorgi & Prendiville, 2017; Yu & Sangiorgi, 2014). Although there has been limited theoretical development of the concept of Design Thinking (Johansson-Sköldberg et al., 2013), and there exists no unanimity upon its exact definition (Clatworthy, 2017), it has gained immense popularity across different fields including: IT and business (Dorst, 2010), as well as healthcare innovation (Carroll & Richardson, 2016). Design thinking pioneer Tim Brown, explains the concept as follows:

> "[Design thinking] uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008, p. 2).

Thus, design thinking involves the continuous balancing of desirability, viability and feasibility of a solution, by applying an explorative and customer-centric approach (Clatworthy, 2017). It is a non-linear and at times 'messy' process, which requires zooming in and out on the problem, generating ideas, creating prototypes, and analysing insights, as shown in Figure 2 (Clatworthy, 2017).

Design thinking typically involves applying a certain type of logical reasoning to solve open-ended challenges, known as 'Abduction' (Dorst, 2010). In abduction problems, organisations know what kind of value they want to create, but they do not yet know 'what' thing (e.g. service, product or other) they want to create, and sometimes do not know 'how' they can deliver the value (which working principle to use). Abduction can be described with a simplified equation (Dorst, 2010):

$$\text{what} + \text{how} = \text{value}$$

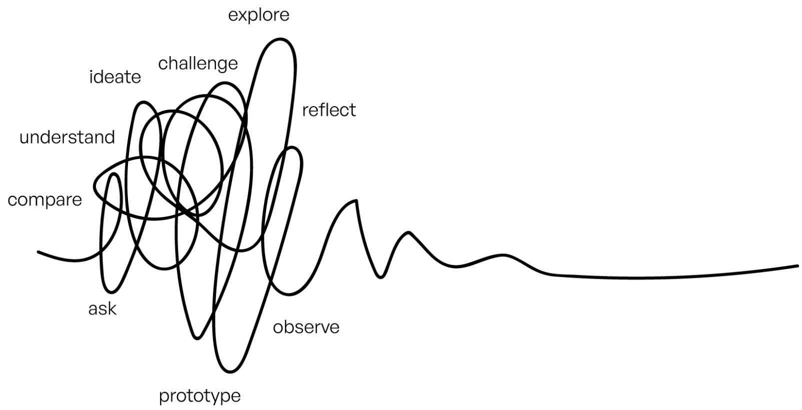

Figure 2. Simplified visualization of the design thinking process in practice – an iterative and non-linear process, adopted from Clatworthy (2017).

Designers are experts at solving abductive problems, by ideating many proposals for how to combine the 'what' and 'how' to create value, improving these concepts iteratively (Dorst, 2010). Both service design and design thinking can be understood as human-centered, iterative, and explorative approaches to designing new services, with barely noticeable differences, when deployed in practice (Torres & Miranda, 2020). Therefore, in this research project, the perspective of Clatworthy (2017) is adopted, namely: service design can be seen as the application of Design Thinking to the service domain. In the next section, the evolving definition of service design is explored.

2.2.2 Service Design

Service design is an emerging field that is yet to establish a consensus regarding the exact definition of the construct (Stickdorn et al., 2011). When service design appeared as a new theoretical field in the 1990s, it was often seen as a phase of New Service Development (NSD), concerned with designing the service interfaces and interaction points (Sangiorgi & Prendiville, 2017). However, over the years, the understanding of what service design entails has expanded, to be understood as a human-centered approach to service innovation (Clatworthy, 2017; Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017; Stickdorn et al., 2011; Torres & Miranda, 2020). This expansion of the scope of the construct makes the expertise valuable throughout the process of designing, developing and implementing new services (Holmlid et al., 2017; Sangiorgi et al., 2017). Moreover, it is generally recognized that a firm cannot design a service outcome, but rather Design for Service, by coordinating the resources in a Service System, that enable the conditions for service (Meroni & Sangiorgi, 2011; Wetter-Edman et al., 2014). A Service System is the ecosystem of stakeholders and resources (e.g. shared-information), and technologies, arranged to support value co-creation (Spohrer et al., 2007; Wetter-Edman et al., 2014).

Table 2. Synthesis of the reviewed scientific literature to understand what service design is, containing the more frequently mentioned characteristics. 'x' indicates the author directly using the characteristic to describe service design activities, while (x) indicates an indirect mentioning.

Characteristics	**Stickdorn et al. (2011)**	**Stickdorn et al. (2018)**	**Meroni & Sangiorgi (2011)**	**Clatworthy (2017)**	**Torres and Miranda (2020)**	**Wetter-Edman et al. (2014)**
Human-centered approach to service innovation	(x)	x	x	x	x	x
Holistic	x	x	x	(x)	x	(x)
Interdisciplinary	x	x	x	x	x	(x)
Involves value co-creation	x	x	x	x	x	x
Uses designerly tools and methods	x	x	x	x	x	x
Uses design thinking	x	x	x	x	x	x

To investigate the most common traits used to describe service design, a literature review was conducted and synthesized in Table 2.

Human-Centered Approach to Service Innovation

The contemporary understanding of service design is that it is a human-centered approach to service innovation (Clatworthy, 2017; Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017; Stickdorn et al., 2018; Torres & Miranda, 2020). Human-centeredness considers all people who interact with a service system, including employees, users, customers, and other stakeholders (Stickdorn et al., 2018). Therefore, it is considered more inclusive than the term 'user-centred' that has commonly been used in the same context. Human-centered design activities include both deploying designerly tools and methods to better understand the users, as well as, to engage stakeholders directly in the design process (Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017). This dual understanding of human-centeredness highlights the importance of both designing for and with stakeholders, to co-create value (Wetter-Edman et al., 2014).

Holistic

The expanding understanding of what service design is, has caused service design practitioners to no longer solely focus on service interfaces and touchpoints with users, but also to investigate and re-design the internal organizational systems that create the conditions for a service experience (Sangiorgi & Prendiville, 2017). In this context, an organization is seen as a complex system of norms, values, actors, beliefs and patterns, which informs how resources can be used (Junginger & Sangiorgi, 2009). Service designers strive to investigate and gain an understanding of people and their experiences in their organisation (Meroni & Sangiorgi, 2011). Thus, service design is taking on a holistic approach, by considering the entire environment surrounding a service (Stickdorn et al., 2011).

Interdisciplinary

Interdisciplinarity is a fundamental part of service design (Clatworthy, 2017; Stickdorn et al., 2011), as well as service innovation (Meroni & Sangiorgi, 2011). Having teams consisting of people with different experience and knowledge are necessary for a holistic approach, to ensure that different perspectives are included in the design and development process (e.g. customers, employees, management, engineers, designers) (Stickdorn et al., 2011). Involving non-designers in the process enriches the field of service design (Blomkvist & Holmlid, 2011).

Value Co-Creation

Modern service designers recognize users as co-creators of value in a service system (Clatworthy, 2017). From this perspective, the lines between the provider and user are increasingly blurred (Meroni & Sangiorgi, 2011). The service provider facilitates value co-creation, by configurating resources in a service system (Wetter-Edman et al., 2014). The value co-creation process can be conceptualized as occurring in three different 'value spheres', being the 'provider sphere', the 'customer sphere', or 'joint sphere' (see Figure 3) (Grönroos & Voima, 2013). Organisations access the customer sphere through interactions in the joint sphere. By understanding and reorganizing the service system and interactions in the joint sphere, service designers can influence the value creation of the customer (Clatworthy, 2017). Service designers therefore engage stakeholders, such as end-users and customers, in the process of co-designing and co-creating service systems (Wetter-Edman et al., 2014). This co-creative facilitation with representative stakeholders is an imperative aspect of service design (Stickdorn et al., 2011).

Designerly Tools & Methods

To better emphasize with the users, and to understand their needs and values, service designers apply a range of tools and methods, adapted from adjacent design disciplines, service marketing and management (Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017). Popular tools include Personas, System Maps, Journey Maps, Service Blueprints, Prototypes, and more (Blomkvist & Holmlid, 2011; Stickdorn et al., 2018).

Based on the findings from the literature review, and for the purpose of this literature review, the following definition of service design was established:

Definition of *Service Design*

Service design is a human-centered, holistic, and interdisciplinary approach to service innovation, which deploys design thinking and an array of designerly tools and methods, to facilitate value co-creation with key stakeholders, such as customers and end users.

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[2] **Value creation under S-D Logic vs Service Logic.** The topic of how value is created in a service system is one of the main differences between S-D logic and Service Logic (Saarijärvi et al., 2017). S-D Logic states that value is co-created between the firm and the beneficiary (Lusch & Vargo, 2006; Vargo & Lusch, 2004), while Service Logic suggests that value can only be created by the customer, where the firm acts as a value facilitator Logic (e.g. Grönroos, 2006, 2008; Grönroos & Voima, 2013). However, since both perspectives agree that value is assessed by the customer based on value in use, or value in context, based on interactions with the firm (Lusch & Vargo, 2006; Grönroos, 2006), this research opts to use the term value co-creation.

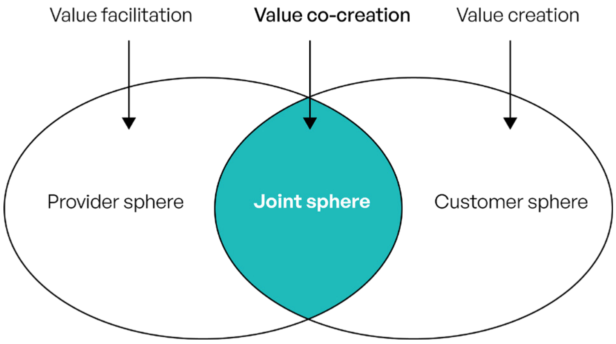

Figure 3. The three spheres where value facilitation and (co-)creation occurs in a service. The image has been adapted from the model presented by Grönroos and Voima (2013).

2.3 Conducting the Service Design Process in Practice

Service design, in practice, can help firms "improve the services that they offer now and to develop whole new value propositions, perhaps based on new technology or new market developments." (Stickdorn et al., 2018, p. 14). Additionally, service design can support manufacturing companies in transitioning towards smart, physical-digital PSS offerings (Solem et al., 2021). It is difficult to visualize the service design research process, due to its iterative and non-linear nature (Stickdorn et al., 2018). However, it is commonly understood that the design process consists of several steps of divergent and convergent thinking (Stickdorn et al., 2018), where the Double Diamond process, presented by the Design Council (2019), has gained significant popularity (Yu & Sangiorgi, 2014) (see Figure 4). The process consists of four main steps: Discover, Define, Develop and Deliver. The Discover step describes the research activities focused on building an understanding of the problem space and owners. In the Define step, the designer redefines the design challenge, based on insight from the discovery phase. The Develop step focuses on ideating potential solutions and engaging stakeholders in co-creative activities. The final Deliver step includes carrying out small-scaled testing activities, validating the relevance of the solution, and making iterative improvements to the final concept (Design Council, 2019).

However, some practitioners have recognized that the Double Diamond does not give a accurate representation of many modern design projects, where designers are increasingly asked to be a part of the development and implementation

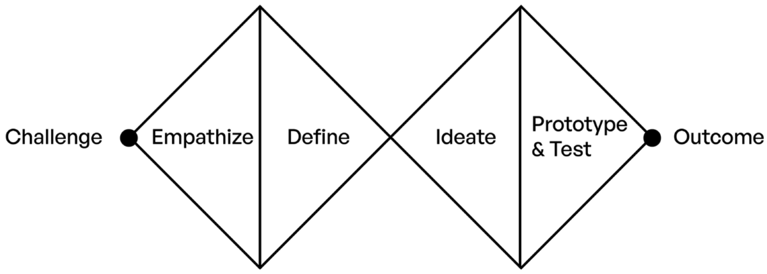

Figure 4. Double diamond process (Design Council, 2019).

process (Chen, 2020). Moreover, service design is sometimes critiqued for being weak in the implementation phase, meaning that many service concepts are often left unrealized (Mulgan, 2014). Mike Chen, Kim Lenox and Jennifer Chang, from the Zendesk design agency, introduced an expanded view on the process for User Experience (UX) design projects, by adding a third diamond that focuses on implementation (Chen, 2020) (see Figure 5).

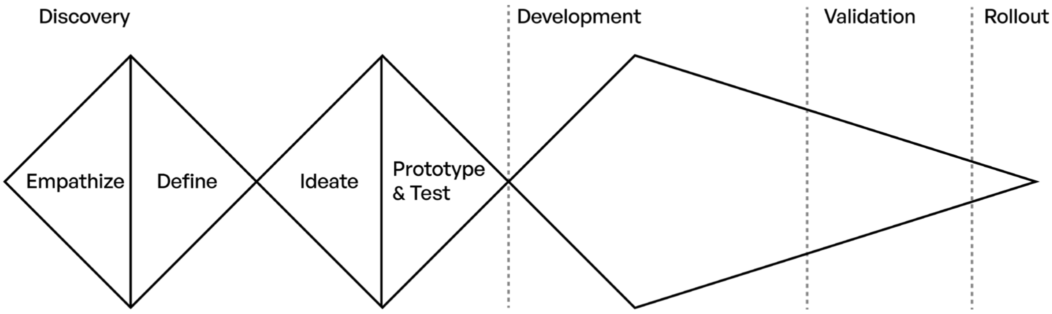

Figure 5. Triple Diamond Design Process, adopted from Mike Chen, Kim Lenox and Jennifer Chang (2020) for Zendesk.

2.4 Service Design Tools

Service designers deploy an array of methods to understand and co-design service systems with a range of internal and external actors (Blomkvist & Holmlid, 2011; Stickdorn et al., 2018). In this section, some of the most common tools deployed are explored.

2.4.1 System Maps

In order to analyze and design a service system, System Maps are often deployed to visualize the constellation of resources in the ecosystem (Stickdorn et al., 2018). A common form of system maps is the stakeholder map. Stakeholder maps visualize the stakeholders involved in the service system, and how they relate to each other, allowing designers to obtain an understanding of the complexities of the system necessary to redesign it (Stickdorn et al., 2018).

2.4.2 Personas

To empathize and imagine stakeholder archetypes, Personas can be created (Stickdorn et al., 2018). A persona is a fictional way to illustrate the needs, wishes and goals of real stakeholders. To make them feel as real as possible, personas are typically given a name, assigned a portrait image, a quote, and given a brief description containing information about demographics, personality characteristics, skills, interests, motivations, needs, frustrations and more (Stickdorn et al., 2011).

2.4.3 Journey Maps

Journey maps allows gap-identification in the service journey, by making the intangible experiences a customer has with the service system visible (Stickdorn et al., 2018). The tool can be used to both gain an understanding of the current system, as well as envision future solutions (Stickdorn et al., 2018).

2.4.4 Service Blueprint

Service blueprints are a standard way of illustrating the processes underlying service delivery and the interaction points between the organization and key stakeholders (Stickdorn et al., 2011). They are often co-created in a collaborative workshop, where multidisciplinary teams come together to create a shared understanding. Service blueprints help identify critical areas of the service, and form a roadmap for service implementation (Stickdorn et al., 2011).

2.4.5 Service Prototypes

To test the concepts that emerge from the design process, Service prototypes can create an early representation of a part of a service experience (Stickdorn et al., 2018). These staged service experiences can come in the form of digital or physical prototypes, mock-ups, wireframes, rehearsals, and desktop walk-throughs, in varying levels of fidelity. Prototypes can help designers engage stakeholders, as well as communicate and evaluate concepts (Stickdorn et al., 2018).

2.4.6 Business Model Canvas

Since it is crucial for service designers to understand the BM they are (re) designing, the Business Model (BM) Canvas, introduced by Osterwalder and Pigneur (2010), is commonly applied (Stickdorn et al., 2018). It helps organizations to visualize a BM using nine building blocks: Customer segment, Customer relationships, Channels, Value propositions, Key activities, Key resources, Key partners, Revenue streams, and Cost structures.

In conclusion, service design tools help interdisciplinary teams understand, explore, ideate, and evaluate multiple perspectives, integrating them into a holistic perspective (Clatworthy, 2017).

3. IoT-Enabled Servitization in Industry 4.0 & Healthcare 4.0

In this chapter, a literature review is conducted on the topic of IoT-Enabled Servitization in Industry 4.0 and Healthcare 4.0. Servitization and Industry 4.0 are two highly relevant trends for the development of the manufacturing industry (Frank et al., 2019b) and healthcare (Aceto et al., 2020). These trends are facilitated by digitalization and new intelligent technologies, such as Internet of Things (IoT), big data, and cloud computing (Aceto et al., 2020; Suppatvech et al., 2019). The following sections introduce servitization, Industry 4.0, IoT, and Healthcare 4.0 (3.1), discuss IoT-Enabled Servitized BMs (3.2), and shed light on the challenges of designing service innovation for the healthcare context (3.3).

3.1 Servitization, Industry 4.0, Internet of Things & Healthcare 4.0

The service economy has grown rapidly over the last decades, contributing to 64% of the global GDP in 2019 (World Bank, 2019). This new marketplace demands firms to embrace customer-centricity (Teece, 2010). Manufacturing companies are increasingly considering servitization as a means to deliver value based on market-demand and customer needs (Frank et al., 2019b; Rymaszewska et al., 2017), gain competitive advantage, and create stable and recurring revenue streams (Baines et al., 2009). Servitization can be defined as "[...] the innovation of an organisations capabilities and processes to better create mutual value through a shift from selling product to selling PSS [Product-Service-Systems]." (Baines et al., 2009, p. 555). PSS are the integration of products and services to create new value for customers (Wallin & Kihlander, 2012). Successful PSS innovation relies both on an understanding of customer needs, as well as the ability to coordinate technology and resources, to facilitate value co-creation (Baines et al., 2009; Bustinza et al., 2017).

Industry 4.0 is viewed as a cyber-physical revolution happening in modern industries, made possible by the development of smart technologies, including Internet of Things (IoT), cloud computing, analytics, and big data (Aceto et al., 2020; Frank et al., 2019a; Frank et al., 2019b). Industry 4.0 often includes both the idea of intelligent and automated manufacturing processes, as well as smart PSS (Frank et al., 2019a). IoT is considered as a key enabler of the Industry 4.0 paradigm

(Aheleroff et al., 2020; Frank et al., 2019a). It can be understood as a network of internet- and sensor-connected entities that can be identified, located and acted upon remotely (Ng & Wakenshaw, 2016), or as "[...] the pervasive presence of a variety of uniquely addressable cooperating objects such as mobile phones, sensors, and actuators" (Aceto et al., 2020, p. 1). IoT allows information to be transmitted to and from the product (Javaid & Khan, 2021), opening up the ability to provide individualized responses to each user (Aheleroff et al., 2020).

The use of smart technologies has also found its place in the healthcare sector, leading to the emerging concept of 'Healthcare 4.0' (Aceto et al., 2020; Saheb & Izadi, 2019). Healthcare 4.0 can be characterized by the integration of the Industry 4.0 technologies, such as IoT, cloud computing, and big data, to create significant alterations to the way the health sector operates (Aceto et al., 2020). Moreover, these technologies unlock several beneficial features, such as: a closed loop design (where manufacturers can leverage information about how products are used in context to make design improvement), predictive maintenance (remote fault identification and monitoring), the creating of novel service offerings, as well as offering Healthcare-as-a-Service (i.e. internet-based Software-as-a-Service solutions to aid patients and healthcare providers) (Aceto et al., 2020).

3.2 IoT-Enabled Servitized BMs

IoT is attracting growing attention from the industry and researchers, as an enabler for new servitized BMs (Suppatvech et al., 2019). The drivers for adopting IoT-enabled servitized BMs are numerous, including: the generation of long-term and steady revenues, building closer realtionships with customers, extending the business, improving the product-service offerings, gaining a competitive advantage and increasing resource utilisation (Suppatvech et al., 2019). IoT has the potential to fashion entirely new value propositions, and therefore, BMs need to be adjusted or redesigned to fit the technology (Bilgeri et al., 2015).

A BM can be seen as the architecture of value creation: it hypothesizes the customers needs, provides compelling value propositions to the customers, and designs the value chain through which value is exchanged for payments and turned into profits (Teece, 2010). It describes the logic that supports the value proposition, as well as the cost and revenue structure for the business. For innovation to succeed in the market, good BM design is imperative. Without this, innovation is unlikely to achieve commercial viability, even if the invention is outstanding (Teece, 2010).

Meanwhile, academic research on IoT-enabled servitized BMs is in a nascent stage (Suppatvech et al., 2019). In their systematic literature review from 2019, Suppatvech et al. strive to further the understanding of how IoT technologies can enable different servitized BMs, by analyzing 74 publications on the topic. Their review found that IoT-enabled servitized BMs were discussed in both Business-to-Business (B2B) and Business-to-Consumer (B2C) context, predominantly in manufacturing and consumer goods. Based on their analysis of the selected publications, the authors identify four 'BM Archetypes', as shown in Table 3.

3.2.1 Add-On BM Archetype

The Add-On BM leverages IoT to create additional services to an existing product or service (Suppatvech et al., 2019). Typically, the customer must buy the core product or service and receive the IoT-enabled service offering, either at an additional cost, or for free. Add-On BM typically come in four different types: (1) Innovative digital services, (2) Facilitate Service Provision, (3) Leverage customer data, and (4) On-demand. Add-On BM are suited for product-oriented PSS and manufacturers, where the added service provides new value to the core product or service. An example of this could be to offer more efficient maintenance, service, or training of the core product as additional value. For further reading, see Appendix A1.

3.2.2 Sharing BM Archetype

The Sharing BM maximizes asset utilization, while the ownership of the product remains with the service provider (Suppatvech et al., 2019). The users pay to use a product or service for a limited amount of time, allowing other users use it as soon as it becomes available. This model has mainly been deployed in the B2C sector (e.g. transport sharing), and may be difficult to achieve for B2B manufacturing companies that are delivering heavier or more complex machinery.

3.2.3 Usage-Based BM Archetype

The Usage-Based BM uses IoT to measure the usage of a product, and the customer either (1) pays per-use, or (2) via a subscription (Suppatvech et al., 2019). This model might be more appropriate for manufacturers that already have a result-oriented PSS offering, by offering a subscription. For a more detailed description of Usage-Based BM, see Appendix A2.

Table 3. IoT-enabled BM archetypes, derived from the systematic literature review by Suppatvech et al. (2019).

BM Archetype	Definition
Add-On BM	IoT is used to create additional functions, or services, to an existing product or service offering. *a) Innovative Digital Service:* Creates hybrid offering by linking an innovative digital service to a product. *b) Facilitate Service Provision:* IoT data is used to make existing product or service offerings more efficient, or less complex. *c) Leverage Customer Data:* Crafts a customised service offering based on the users' data. *d) On-Demand:* Additional service or information is made available upon customer request.
Sharing BM	IoT data allows the customer to pay to use a product or service for a limited amount of time, allowing other users use it when available.
Usage BM	IoT data allows the customer to pay for their usage of a service. a) *Pay-Per-Use:* The customer pays for the amount of usage. b) *Subscription:* The customer pays subscription fee for unlimited access
Solution-Oriented BM	Utilises and integrates IoT to provide their customers with a certain outcome or solution. a) *Availability:* The customer pays to ensure that they have unlimited access to functioning technology, with the promise of maintenance in the case of malfunctioning. b) *Optimization or Consultancy:* The service provider uses IoT data to optimize practices of customer.

3.2.4 Solution-Oriented BM Archetype

The Solution-Oriented BM utilizes and integrates IoT to provide their customers with a certain outcome or solution (Suppatvech et al., 2019). There are two categories of solution-oriented BMs: (1) Availability and (2) Optimization or Consultancy. For a more detailed description of Solution-Oriented BMs, please refer to Appendix A3.

3.2.5 Choosing a BM

When choosing an appropriate BM to deploy, it is important to consider the firm's existing PSS (Suppatvech et al., 2019), as well as the necessary capabilities needed to provide the system (Jovanovic et al., 2019). Regarding their ability to generate value for the company, the most opportunities are found in the add-on and solution-oriented archetypes. This is because the usage of IoT is more deeply integrated in the value offering (Suppatvech et al., 2019), than in the usage and sharing BMs. Solution-oriented and Add-on BMs may be promising alternatives for manufacturing companies expanding towards servitization (Suppatvech et al., 2019). However, Solution-oriented BMs could be more complex, posing a bigger challenge of implementation than Add-on models. Therefore, Suppatvech et al. (2019) recommend that traditional manufacturers begin IoT-enabled servitization through the add-on BM archetype. This aligns with the statement made by Jovanovic et al. (2019): "...managers are cautioned against attempting to simultaneously deliver the full range of services at the founding stage" (p. 483).

3.2.6 Concerns Regarding IoT-Enabled Servitization

Although there are several mentioned benefits for manufacturers to implement IoT, there are several additional concerns that IoT-enabled service models need to address (Ng & Wakenshaw, 2016). Such concerns include privacy and data security (Ng & Wakenshaw, 2016; Suppatvech et al., 2019), as well as requiring high stakeholder participation, new ways of customer interaction, data management expertise, resolving technical issues, making a high initial investment, and matching customer needs (Suppatvech et al., 2019).

Customer data must be managed carefully and appropriately, demanding that the organisation holds the necessary skills and resources to manage privacy and security (Suppatvech et al., 2019). This is especially important as IoT tends to generate large amounts of data. Technical issues need to be resolved, as well as a high cost with initial development of products must be considered (Suppatvech et al., 2019). Additionally, skills in new forms of stakeholder involvement and interaction need to be developed within the organisation (Suppatvech et al., 2019). Moreover, as argued by Ng and Wakenshaw (2016, p. 23): "… research is needed to expand on the understanding of vulnerability in digital domains, and how mechanisms such as perceived control and trust could reduce vulnerability and therefore be built into firms' offerings". Thus, manufacturing firms pursuing IoT must find ways to address and overcome these challenges, to implement reliable IoT-Enabled Servitized BMs.

3.3 Service Innovation for Healthcare 4.0

The healthcare sector's service environment often causes challenges for service designers, for an array of reasons, e.g. high complexity, scale, variety, close relationship with, as well as dependency on, clients, hierarchal nature, highly socio-technical settings, as well as its position in a wider societal context (Robert & Macdonald, 2017). Furthermore, new healthcare technologies often struggle to be adopted by healthcare organizations (Plsek, 2003). The 'legacy-system' (status-quo) may try to resist those who introduce change, e.g. due to the time limitations of the practitioners, or insufficient support from management (Rodrigues & Vink, 2016). Healthcare professionals may feel like innovation removes some of their autonomy in determining how to carry out their job (Bronsoler, 2020). Thus, it is important to develop a deep understanding of the needs, context, and day-to-day activities of stakeholders, when designing for healthcare (Carroll & Richardson, 2016). These findings highlight the importance of stakeholder involvement in the design of healthcare technology innovation (Bronsoler, 2020), and the applicability of Design Thinking and service design in the healthcare domain (Carroll & Richardson, 2016; Clack & Ellison, 2019).

Although there is no consensus on one correct way to carry out development for healthcare innovation (Robert & Macdonald, 2017), one framework that has gained considerable popularity is the Medical Research Council (MRC) Framework (Craig et al., 2008; MRC, 2008) (see Figure 6). The MRC framework includes four steps that can be applied non-linearly and iteratively: Development, Feasibility/ Piloting, Evaluation, and Implementation, with the aim to increase the chance of successful adoption (MRC, 2008). However, the MRC has been criticised for neglecting the role of the context surrounding the healthcare interventions (Bonell et al., 2012; Fletcher et al., 2016). To obtain an understanding of the contextual components that hinder or facilitate the adoption of new service interventions, or to identify variations in intervention delivery, carrying out qualitative research is essential (Bonell et al., 2012). Furthermore, the MRC framework advocates for the involvement of key stakeholders throughout the design process, to gain a better understanding of the needs of the target group (MRC, 2008). Thus, the MRC can benefit from the human-centered field of service design, and vice versa.

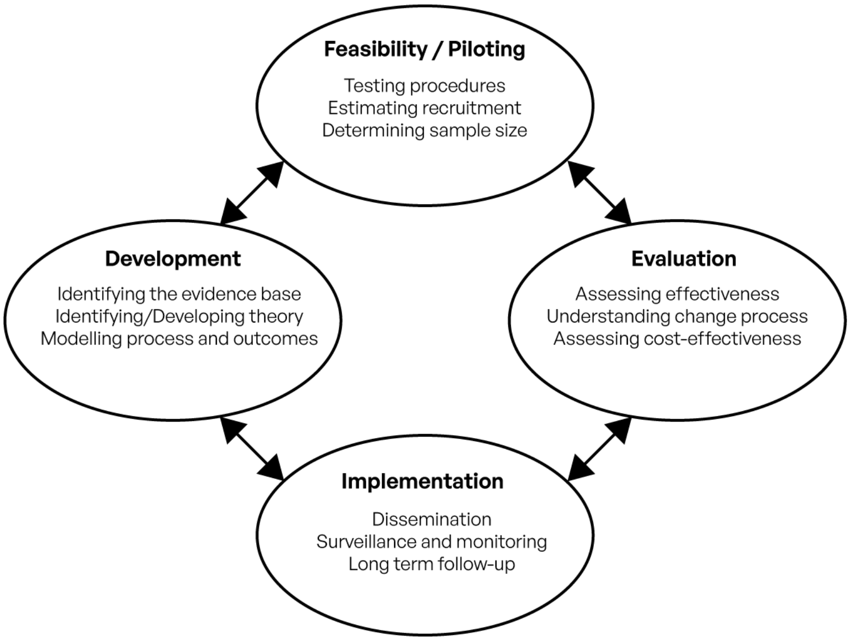

Figure 6. The Medical Research Council Framework for the development and evaluation of complex healthcare interventions (MRC, 2008).

A healthcare organisation's decision to invest in a healthcare innovation is largely influenced by the perceived relative advantage of doing so, i.e. "The more benefit people anticipate from adopting the innovation relative to what they now do, the more rapidly it will diffuse." (Cain & Mittman, 2002, p. 7). To help innovation diffuse in the healthcare context, being able to calculate the Return of Investment (ROI) (Cain & Mittman, 2002), and provide a strong Business Case for increased efficiency or reduced costs, is of importance (Oderanti et al., 2021). However, in cases where it is difficult to make promises regarding a certain ROI, customer testimonies and experiences may be especially important (Cain & Mittman, 2002).

This chapter has discussed research in the filed of IoT-enabled servitization in Industry 4.0 and Healthcare 4.0. The findings from this literature review will serve as a foundation for the service design activities carried out on a case with the healthcare technology manufacturer esense.

Part B. Domain Knowledge

4. Occupational Safety & Health in Nursing Home Context

The aim of this research was to explore service design's role in IoT-Enabled servitization, for manufacturing firms targeting the Healthcare 4.0 context. To do so, a RTD approach was applied (Jonas, 2014) by conducting service design activities for the healthcare manufacturing brand esense. Esense is committed to help healthcare professionals attain healthier ways of working, and reduce the physical load they experience during the pushing and pulling of heavy equipment (Esense, n.d.-c). To design for this context, it was necessary to obtain a certain domain knowledge regarding the problem of occupational physical demand in healthcare (4.1), the health implications of physical overload during patient transfer (4.2), and the Dutch legislation that strives to prevent work-related illnesses (4.3). This chapter summarizes key findings on these topics, which helped inform the HWaaS design project for esense.

4.1 Occupational Physical Demand & Sickness Absence in Nursing Homes

In the Netherlands, exposure to occupational physical demand is one of the biggest threats to employee health (Health Council of the Netherlands, 2012). Employees with physically demanding professions, such as healthcare workers, have a heightened risk of experiencing long-term sickness absence, musculoskeletal disease, disability pension, and prematurely exiting the market (Sundstrup et al., 2018). Since 2018, the healthcare sector has had the highest sickness absence, reaching 5.7% in 2019 (CBS, 2020b), with professionals working in nursing homes having the highest sickness absence of all groups, at 6.8% in 2019 (CBS, 2020b), and 8.1% in 2020 (AZW, 2021). 28.1% of healthcare workers do heavy physical labor, being the third highest of all the sectors included in the National Working Conditions Survey (Nationale Enquête Arbeidsomstandigheden) from 2019, surpassed only by construction (34.3%) and agriculture (32.8%) (Hooftman et al., 2020). In 2017, musculoskeletal complaints made up 27% of occupational disease reported in the Netherlands, the second biggest category, following mental health issues at 57% (van der Molen et al., 2018). These numbers illustrate that physical overload in healthcare must be tackled to protect caregivers' health.

Working as a caregiver is a physically demanding profession, with a high risk of developing musculoskeletal diseases (Andersen, 2020). Meanwhile, a growing challenge in the Netherlands, as well as many other countries, is an aging population (CBS, 2014, 2020a; United Nations, 2020). The global population aged 65 years and above is projected to increase from 9.3% in 2020, to 16.0% in 2050 (United Nations, 2020). Meanwhile, there is a shortage of healthcare professionals in the nursing home sector. In 2020, 63% of vacancies were difficult to fill (AZW, 2021). A recent study by Merkus et al. (2019) shows that older healthcare employees may be facing higher relative strain because of physical demands at work, which may lead to worse health effects than for younger employees. Furthermore, remaining physically strong may not be enough to prevent unhealthy muscle activity patterns over a long time, and to reduce the risk of musculoskeletal disorders (Merkus et al., 2019). Therefore, to attract, retain, and protect an aging workforce, it is important that actions are taken to improve working conditions and reduce the physical load caregivers endure in the workplace.

4.2 Physical Overload During Pushing, Pulling and Patient Transfers

Caregivers need to apply high pushing and pulling forces in their job (Health Council of the Netherlands, 2012). Pushing and pulling counts as one of the five biggest work-related risk-factors to developing musculoskeletal disorders in the Netherlands (van der Molen et al., 2018), linked to back and shoulder complaints (Health Council of the Netherlands, 2012). Several studies have shown that after 12 months of pushing and pulling, almost 25% of employees are likely to develop physical complaints in their lower back or shoulder (Health Council of the Netherlands, 2012). Work-related back pain is causing caregivers considerable suffering, and demands high costs of healthcare organizations (Knibbe & Knibbe, 2012) related to sickness absence, rehabilitation, as well as work disability (Health Council of the Netherlands, 2012). Therefore, to protect healthcare professionals from developing musculoskeletal diseases, prevention is key (Jensen et al., 2012; Knibbe et al., 2007; van der Molen et al., 2018).

Meanwhile, studies regarding pushing and pulling rely on self-reported exposure to physical load, since there have been no ways to measure this type of data objectively and on a larger scale (Health Council of the Netherlands, 2012). Similarly, assessing the efficiency of interventions, without interfering with practitioners too much, remains a challenge (Knibbe & Knibbe, 2012). This suggests a need for objective and unobtrusive data measurement regarding pushing and pulling forces, as well as to monitor the success of interventions.

Physical complaints in caregivers can often be linked to patient handling activities (Koppelaar et al., 2010). In elderly care, clients with limited mobility need help with being lifted and transported (Knibbe et al., 2007; Koppelaar et al., 2010) in some cases more than 12 times per 24 hours (Knibbe et al., 2007). Devices, such as floor-driven patient lifts or ceiling hoists, are required to lift and transfer passive, or nearly passive, clients (see illustration in Figure 7) (Knibbe et al., 2007; Koppelaar et al., 2010). However, despite there existing a link between the persistent use of transfer aids and a reduced risk of back injuries (Andersen et al., 2013), compliance is often sub-par in practice (Koppelaar et al., 2010). The adoption of patient lifts may be hindered by the skills of the caregiver (Andersen, 2020), the availability of the devices, spatial constraints (Andersen, 2020; Knibbe et al., 2007), the limited implementation of ceiling hoists in Dutch nursing homes, or installed ceiling hoist being limited to one room (Knibbe et al., 2007).

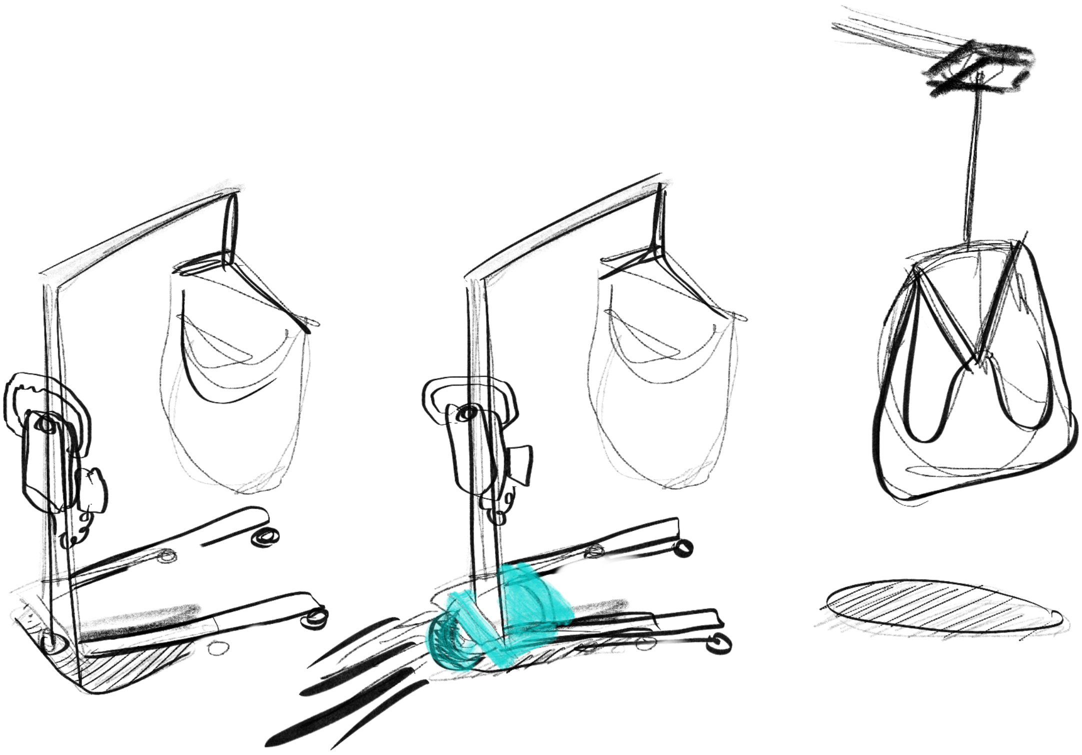

Figure 7. Sketch of the type of patient transfer devices commonly used in nursing homes: floor-driven patient lifts (manual one the left, e-driven in the middle) and ceiling hoists (on the right).

Koppelaar et al. (2010) identified three main drivers for patient lift adoption in healthcare, being (1) caregiver motivation, (2) the presence of clear ergonomic policies for the user of the patient lift, and (3) the presence of back-pain symptoms in the caregiver in the last 12 months. However, as expressed by Koppelaar et al. (2010, p. 664): "Apparently, having had back complaints triggers nurses to use lifting devices when required. Lifting devices are, however, intended to prevent both the onset as well as the recurrence of back pain episodes. Thus, nurses without back complaints should be encouraged to use lifting devices when required in order to prevent the onset of these complaints.".

To encourage ergonomic working habits, healthcare organisations in the Netherlands must have 'Ergo Coaches' present in each location (Knibbe et al., 2007). Ergo coaches are caregivers with additional education regarding ergonomics in healthcare (Knibbe et al., 2007; Koppelaar et al., 2010). Moreover, the level of intervention to combat unhealthy working habits varies between healthcare organisations, where some organisations could be classified as innovators, taking more initiative than other organisations (Knibbe et al., 2007). The reason for healthcare organisations taking insufficient measures is often financial (Knibbe et al., 2007). Furthermore, in order to promote healthy change in organisations, a customized approach may be necessary (Knibbe et al., 2007). Involving the caregivers as key stakeholders is important, as expressed by Knibbe et al. (2007): "Working with Ergo Coaches on these types of wards can facilitate empowerment of the nurses themselves in this implementation process and can ensure and stimulate commitment" (p. 211).

4.3 Occupational Safety & Health Regulation

With an aging workforce, providing a safe working environment with sustainable employment conditions, is imperative (Inspectorate SZW, n.d.). In the Netherlands, the Inspectorate SZW, which constitutes a part of the Ministry of Social Affairs and Employment (Het Ministerie van Sociale Zaken en Werkgelegenheid, or 'SZW') is the governmental body that monitors employer and employee compliance with regulation regarding Occupational Safety and Health (OSH). The SZW strives to provide healthy working conditions for all, and to reduce the sickness absence caused by unsafe or unsustainable employment situations (Inspectorate SZW, n.d.). In doing so, employer costs associated with sickness absence can be lowered, since in the Netherlands, an employer is obliged to pay an employee on sick absence at least 70% of their salary (Dutch Working Conditions Legislation, 2017). Furthermore, costs related to the recruitment of new employees, or insurance premiums, can also be lowered by reducing sickness absence (Inspectorate SZW, n.d.).

With respect to work safety and health, there are several regulations which the Inspectie SZW supervises, (Dutch Working Conditions Legislation, 2017; Inspectorate SZW, n.d.) as shown in Table 4. Firstly, there is The Working Conditions Act ('Arbeidsomstandighedenwet', or 'Arbowet') which provides general guidelines for how employers and employees should address safety and health in the workplace. This act also gives the Inspectorate SZW certain authority to e.g. interrupt work if needed. Secondly, the Inspectorate SZW also follows the Working Conditions Decree ('Arbobesluit'), which covers a variety of topics related to health and safety at work, such as noise, vibrations, and dangerous substances. Thirdly, the Working Conditions Regulations ('Arboregeling') is updated frequently and contains detailed provisions about occupational health topics. On an European level, the EU information agency for occupational safety and health (EU-OSHA) works to improve working conditions in Europe (Dutch Working Conditions Legislation, 2017). For further reading regarding regulation on EU level, refer to Appendix B.

Table 4. An overview of the key acts, degrees and regulation that guide occupational health and safety in the Netherlands.

Act, Decree or Regulation	Description
Working Conditions Act (Arbowet)	General guidelines for how employers and employees should manage safety and health in the workplace. However, the act does not state legal limits for pushing and pulling.
Working Conditions Act (Arbowet)	Addresses a variety of workplace health and safety topics.
Working Conditions Regulation (Arboregeling)	Frequently updates occupational health and safety provisions.
Major Accidents Legislation	Legislation on how to prevent and handle major workplace accidents.

A core part of the Dutch Occupational Safety and Health (OSH) legislation system is that all employers must provide an OSH service to their employees, or to contract an occupational physician (Dutch Working Conditions Legislation, 2017). These contracts are often external to the organisation. The physician or OSH service has a duty to (1) assist employees that cannot work due to illness, (2) review and revaluate the risk assessment, (3) carry out periodic occupational health examination, and (4) carry out medical examination pre-employment. Furthermore, the employer must also appoint one internal employee with knowledge of OSH, often called a designated worker, prevention worker, or Arbo -Coordinator (Dutch Working Conditions Legislation, 2017; Preventie Medewerker, n.d.). This employee will, amongst other things, help with risk assessment, and evaluation, related to the working conditions (Dutch Working Conditions Legislation, 2017). Additionally, employers are obliged to inform the Inspectorate SZW immediately if a work-related accident results in hospital admission, permanent injury, or fatality (Inspectorate SZW, 2019).

The Working Conditions Act does not set specific legal limits for pushing and pulling forces, ("Arbeidsomstandighedenbesluit," 2021; Health Council of the Netherlands, 2012; SZW, n.d.-b). However, recommendation catalogues have been developed in collaboration between employers and employees to specify how they intend to comply with governmental regulations, known as the 'Arbocatalogus' (SZW, n.d.-a). These guidelines suggest that pushing forces should not exceed 20 kg with two hands (Knibbe et al., 2007), and 15 kg with one hand (Arbocatalogus VVT, n.d.). If a force over 20 kg is required to move an object, powered transfer devices should be used (Knibbe et al., 2007).

This chapter reviewed articles and literature on the common issue of physical overload in healthcare, and how it influences sickness absence. It also introduced Dutch legislation on the topic of OSH for the healthcare sector. This information helped inform the research for the HWaaS case for esense, explained in the following chapters.

Part C.
Methodology

5. Research Methods

There is a need for the scientific community to engage in practice-based research activities to inform the discourse on servitization for manufacturers, instead of merely reporting on current activities in the industry (Baines et al., 2009). This research aims to bridge this gap, by conducting Practice-Based Design Research (PBDR) (Kroll et al., 2020) and designing an IoT-enabled PSS for healthcare manufacturer esense in the HWaaS project. This chapter describes PBDR (5.1), the deployed design process (5.2), as well as the methods used for data collection and analysis (5.3). The outcomes of the design research process are described in Chapter 6, 7, 8, and 9.

5.1 Practice-Based Design Research

Design Research is the application of design activities to generate new knowledge (Zimmerman et al., 2007). It is characterized by the researcher engaging in reflective practices, as well as communicating the gathered findings (Motta-Filho, 2017). Practice Based Design Research (PBDR) takes place in practice, on real world experiences (Kroll et al., 2020). Research Through Design (RTD) is an application of PBDR where the researcher takes on an active role in the design process (Jonas, 2014; Kroll et al., 2020) and designerly methods play a formative role in knowledge generation (Stappers & Giaccardi, 2017). PBDR can generate valuable insights regarding dynamics in socio-technical environments, that could go unnoticed using other forms of research (Kroll et al., 2020). Therefore, this research adopted a RTD approach to PBDR, with the goal of generating knowledge regarding the role of service design in creating IoT-enabled PSS for healthcare technology manufacturers. To do so, an array of service design tools and methods were deployed.

5.2 Design Process

Deploying phases of divergent and convergent thinking is a standard skill-set of designers. As expressed by Stickdorn et al. (2018): “At the core of any design process is the recurring pattern of creating and reducing options” (p. 84). A common method of visualising these steps is the Design Council’s (2019) Double Diamond Process (Yu & Sangiorgi, 2014). However, since the service design field is often criticised for neglecting the implementation phase of service innovation (Mulgan, 2014), this research project adopted the Triple Diamond Design Process (see Figure 8), previously deployed in the field of User Experience (UX) Design (Chen, 2020). The Triple Diamond makes the implementation phase explicit, with the addition of the third diamond. Some adaptations to the visualisations were made to match design process undertaken in this project, including: (1) an extended discovery phase to illustrate the need for to gain a good understanding of the complex service context, that is healthcare (Craig et al., 2008), and (2) the implementation phase which was inspired by the MRC (2008) framework, making phases of pilot-testing, evaluation, market implementation, as well as long-term follow up explicit. Due to the scope and time limitation of this project, the first and second diamond were completed, as well as the initial phase of the third diamond, covering the stages of: Discover, Define, Ideate, Validate and Final Concept as recommendations for the Pilot phase and implementation.

Moreover, successful service innovation relies on the ability to build a sound BM (Stickdorn et al., 2018). To develop a new IoT-enabled BM, elements of the Lean (Start-Up) approach (Ries, 2011) were integrated into the design process. The Lean approach helps businesses identify and test key assumptions regarding their project through market experimentation and customer feedback, in an iterative and time-efficient way (Maurya, 2012; Ries, 2011). Based on the guidance provided by innovation experts Wordlenig, throughout the HWaaS research, some Lean tools were integrated in the design process, including the Lean Canvas (Maurya, 2012), Assumption Mapping (Bland, 2020; Gothelf & Seiden, 2021) and Value Proposition Canvas (Strategyzer, 2020). These tools are further explained in 5.3.

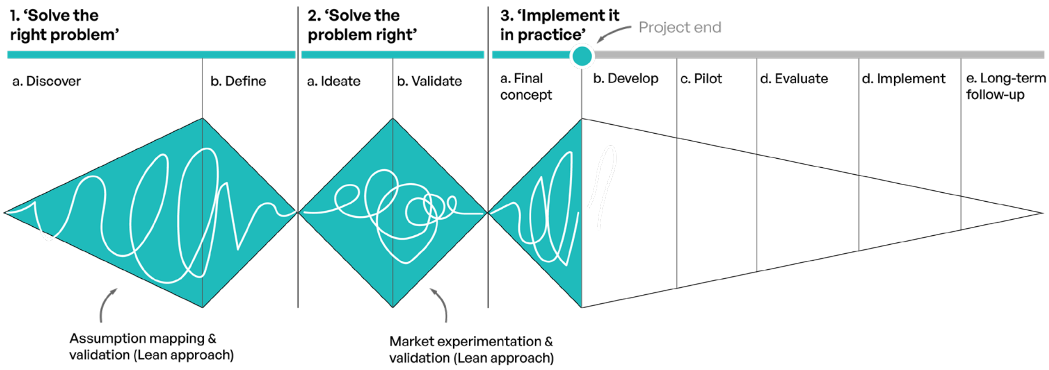

Figure 8. The Triple Diamond Design Process, adapted from Design Council (2019) and Chen (2020), taking inspiration from the MRC (2008) framework, as well as the Lean approach to business innovation (Ries, 2011).

5.2.1 Phase 1: Discover

In the first phase of the Triple Diamond Design Process, namely 'Discover', research activities are explorative in nature. The purpose of this phase is to understand the internal system of the service provider (Sangiorgi et al., 2017), gaining necessary domain knowledge regarding healthcare as a service environment (Robert & Macdonald, 2017) (as described in Chapter 4), empathizing with key stakeholders (Stickdorn et al., 2018) and explore the problem space (Design Council, 2019). The research methods and tools deployed in this phase included Desk Research, Semi-Structured Interviews, Co-Creative Workshops, Stakeholder Mapping, and Personas (e.g. Stickdorn et al., 2018), as well as methods borrowed from the Lean approach, including Assumption Mapping (Bland, 2020). Descriptions of these methods and tools can be found in 5.3, and the activities and outcomes of the Discover phase are described in Chapter 6.

5.2.2 Phase 2: Define

During the second phase – 'Define' - analysis and synthesis activities were implemented to converge the collected data towards a redefined problem statement (Design Council, 2019). Here, the Affinity Diagram (Baxter et al., 2015) was used as a resourceful tool for analysis of qualitative data, as well as Empathy Mapping, and Personas (Ferreira et al., 2015). Descriptions of these methods and tools can be found in 5.3. Concluding this phase, a clearer view of the scope of the project was established. The activities and outcomes of the Discover phase are described in Chapter 7.

5.2.3 Phase 3: Ideate

In this phase, the solution space was explored (Design Council, 2019), by creating a Value Proposition Canvas (Strategyzer, 2020) anchored in the problems identified in the Define phase, and using Brainwriting (Litcanu et al., 2015) to generate several concepts for the HWaaS project. Descriptions of these methods and tools can be found in 5.3. The detailed steps and outcomes of the Ideate phase are described in Chapter 8.

5.2.4 Phase 4: Validate

In the fourth phase – Validate - research focused on conducting experimentation in the target market, with the guidance of innovation experts Wordlenig. Companies that are exploring servitization need to validate their hypotheses in the target market (Teece, 2010; Vargo & Lusch, 2004). Therefore, a Service

Prototype (Stickdorn et al., 2011) was developed for the esense HWaaS concept, and evaluated in a Prototyping Session (Stickdorn et al., 2018). This session was implemented a Semi-Structured Interview approach (Baxter et al., 2015), where a Digital Prototype (Stickdorn et al., 2018) was shared with the target market for feedback. Descriptions of these methods and tools can be found in 5.3. The detailed steps and outcomes of the Validate phase are described in Chapter 9.

5.2.5 Phase 5: Final Concept & Recommendations for Pilot

Based on a positive response from the target market during the 'Validate' phase, it was decided that esense would continue the development of the HWaaS concept into a pilot phase. Therefore, the fifth phase was entered – Final Concept - where the findings from the user feedback sessions were turned into a future PSS proposal. To guide the transition into a PSS, Service Blueprints and a Digital Prototype were co-created with internal stakeholders in online Co-Creative Workshops (Stickdorn et al., 2018).

To avoid the common service design pitfall of insufficiently carrying over concept into implementation (Mulgan, 2014), several steps were taken to support the implementation phase. These included creating a simplified Digital Prototype and Service Blueprint (Stickdorn et al., 2018) for the pilot phase. Moreover, several meetings were held to plan and realize the pilot.

The descriptions of the methods and tools deployed in this phase can be found in 5.3, with the research process of this phase described in Chapter 10.

5.3 Methods for Data Collection, Analysis & Synthesis

There exist several ways to collect and analyze data for service design research (Stickdorn et al., 2018). This section highlights the methods deployed in the HWaaS project conducted together with esense, as described in Part D of this report - Design Research for HWaaS. This section can be used as a reference when reading Part D.

5.3.1 Desk Research

Desk Research, or Secondary Research, involves investigating and synthesizing existing research, to gain relevant knowledge from the field, and "... simply to avoid reinventing the wheel and stand on the shoulders of giants ..." (Stickdorn et al., 2018, p. 118). This may include e.g. reading online material, books, and articles on the topic. Performing this type of research is an important part of starting any research process.

5.3.2 Semi-Structured Interviews

Interviews with key stakeholders are an important primary research method for service designers. By speaking to different stakeholders, the researcher can obtain an insight into different stakeholder perspectives (Stickdorn et al., 2018), and integrate them to create a more holistic view (Baxter et al., 2015). In this research, Semi-Structured Interviews were opted for. Semi-structured interviews make use of previously prepared questions, but also allow deviation from these questions to follow interesting insights gathered from the participants (Baxter et al., 2015). This interview method was deployed in several phases throughout the project, to gain the perspective of esense employees and external stakeholders, including customers, end-users, healthcare technology dealers, as well as, experts in the field of ergonomics.

5.3.3 Stakeholder Co-Creation

At several moments throughout the research, stakeholders were involved in co-creating Boundary Objects, which are artefacts that make communication about certain intangible things easier for multidisciplinary teams (Stickdorn et al., 2018). In this research, creating the Stakeholder Maps, Customer Journey Maps, and a BM Canvas involved participation from esense employees. Additionally, to create a better understanding of the internal process of healthcare professionals, a short Stakeholder Mapping and Journey Mapping activity was conducted together with healthcare professionals as a part of the prototyping session.

5.3.4 Analysis

To analyse the rich data collected in the stakeholder interviews, Affinity Diagramming was deployed (Baxter et al., 2015). Affinity Diagrams are used for qualitative data analysis, by writing down researcher insights on 'sticky notes' (digital or physical), and rearranging these in groups, creating visual cues of emerging themes. This method of analysis was chosen because it helps break down complex issued into focused sub-categories, and is relatively time-efficient (Baxter et al., 2015).

5.3.5 Service Design Tools

There exist a number of tools that service designers can deploy when implementing research activities for service innovation, as illustrated in Chapter 2.4. In this project, some common service design tools were deployed. These included Stakeholder Mapping, Empathy Mapping, Personas, Customer Journey Maps, Service Blueprints, and Service Prototypes. Below, short descriptions for each method are included, derived from Stickdorn et al. (2018).

Stakeholder Maps are used to visually illustrate the network of actors involved in a service system, and can reveal relationships, bottlenecks, the flow of information and power hierarchies.

Empathy Maps and ***Personas*** can be used to synthesize information gathered from primary or secondary research, and visualize the people affected by the service.

Journey Maps are used to visualize a stakeholder's experiences and interactions with e.g. a service system, over a time period. They may help designers uncover gaps in the service experience that may be addressed in a new service offering.

Service Blueprints are closely related to Journey Maps, by visualizing the sequential steps and actions that occur from the customer-side, as well as front-stage, and back-stage, of the service provider's internal system.

Service Prototypes orchestrate a certain part of a service experience, to be co-created, shared, or tested with key stakeholders. These come in several forms, e.g. Digital Prototypes, Physical Objects, Service Advertisement, and more. In this project, Digital Prototypes were deployed, by creating interactive digital User Interfaces (UI), shared in a prototyping session.

5.3.6 Lean Tools

Several tools derived from the Lean Start-Up Approach (Maurya, 2012; Ries, 2011) were leveraged, to help develop an IoT-enabled BM (Suppatvech et al., 2019) anchored in quick and iterative experimentation and validation with the target market. These tools included The Lean Canvas (Maurya, 2012), Assumption Diagramming (Gothelf & Seiden, 2021), and the Value Proposition Canvas (Strategyzer, 2020). These are explained briefly below.

The Lean Canvas by Maurya (2012) builds upon the original BM Canvas by Osterwalder and Pigneur (2010), but is adapted to fit the lean approach. The template helps innovators write quick and concise descriptions of their BM idea on a portable 1-page template.

Assumption Mapping (Gothelf & Seiden, 2021) can be used to identify the core assumptions, as well as the riskiest assumption regarding a project (Maurya, 2012), which need to be validated through research.

The Value Proposition Canvas is a template that can be used to shape a value proposition, which is directly anchored in customer problems (Strategyzer, 2020). This tool helps firms and start-ups achieve a better fit between the proposed offering and the market.

This chapter has described the research methodology adopted in this project. Next, Part D will describe the process of applying an RTD approach to design an IoT-enabled PSS for the healthcare technology manufacturer esense, as well as discuss the core findings from this approach.

Part D. Design Research for HWaaS

Project Brief

Case Research Questions

The goal of the HWaaS project was to investigate how esense can design an IoT-enabled PSS, moving from being a product-oriented company, to offering services and solutions. This entailed investigating how the existing esense resources (e.g. knowledge, technology, skills, employees) can be coordinated to create new value for customers, as well as form a desirable, feasible and viable BM. More specifically, esense was interested in investigating how their IoT-patient lifts could help healthcare organizations tackle the issue of physical overload that occurs during patient transfer activities.

Therefore, a case-specific main research question was formulated.

> **Case RQ: How can service design be leveraged to create an IoT-enabled Servitized BM for esense, which allows healthcare organizations to promote caregiver health during patient transfer?**

Several case-specific sub-research questions were formulated to guide the research phase:

> **Case SRQ1.** What internal resources exist and can be created within esense that can facilitate an IoT-enabled PSS?

> **Case SRQ2**. What challenges do healthcare organisations face regarding physical overload in patient transfer moments?

> **Case SRQ3**. How can a Service Design be deployed in HWaaS project?

> **Case SRQ4**. How can IoT-enabled servitization BMs be adopted by esense in this new PSS?

The HWaaS case provided an example of applying PBDR, through a RTD approach, to generate knowledge (Stappers & Giaccardi, 2017) that could inform the general discourse on IoT-enabled servitization for manufacturers in the Healthcare 4.0 context.

Initial 'Riskiest' Assumptions

Assumption Mapping (Gothelf & Seiden, 2021) was carried out at the beginning of this project to identify which underlying assumptions were driving HWaaS. Assumption maps are a tool used to map the assumptions underlying a project, according to their risk level and difficulty of validation (see initial Assumption Map in Appendix C). The 'riskiest assumptions' (being the most important and difficult to validate) were used to guide the project research, and included:

1. Physical overload caused by the incorrect use of patient lifts leads to physical complaints and sickness absence in caregivers.

2. Healthcare organizations are interested in receiving objective data collected by the patient lifts (using IoT) to measure and monitor the physical load that occurs on the work floor.

3. Dealers are interested in receiving remote data regarding the status of the patient lifts, to trouble-shoot and conduct more efficient maintenance.

4. Esense can build a simple business-case by calculating the ROI from the use of HWaaS in reducing sickness absence.

5. Healthcare organizations are interested in the HWaaS concept and value proposition.

6. Esense can build a desirable, feasible, and viable IoT-enabled BM around the HWaaS project.

Through market experimentation, as explained in Chapter 6-10, these assumptions were reviewed and updated, with the end goal of being either validated or rejected.

6. Discover

6.1 Introduction

The first phase of the Triple Diamond Design Process is 'Discover'. This phase contains explorative research, since, in order to successfully design service systems that enable value co-creation, designers must form an understanding of the users, their contexts, activities and experiences (Wetter-Edman et al., 2014). Without gaining an understanding of organisational capacities, service design concepts are often left unrealized (Mulgan, 2014). Moreover, healthcare forms an especially complex service context to design for, dues to its high complexity, scale, variety, interdependencies with clients, hierarchal internal structures, and highly socio-technical environment (Robert & Macdonald, 2017). Therefore, this phase of the research process aimed to answer the case sub-research questions 1-3, and obtain a working understanding of the current service system.

6.2 Organisational Context

Service systems consist of people, technology, and resources (e.g. skills, information, and knowledge) (Spohrer et al., 2007; Wetter-Edman et al., 2014). Therefore, in order to facilitate a new service system, practitioners must gain a working understanding of the existing organizational resources, and reconfigure them to meet customer needs (Wetter-Edman et al., 2014). To obtain an understanding of esense's organisational resources and internal context, several methods of data collection were used, including Desk Research, informal Interviews with employees, and Co-Creative Workshops (e.g. Stickdorn et al., 2018). Through this research, several key organisational resources were identified, detailed in this section.

6.2.1 Technologies

Technologies interact with people in a service system (Spohrer et al., 2007; Wetter-Edman et al., 2014). The esense product portfolio consists of several technologies that reduce and measure the physical load needed to push, pul,l or manoeuvre heavy mobile equipment (Esense, n.d.-a). These products include Patient Lifts (with accessories), the stand-alone esense electric drive support system that can be integrated into other mobile products, and the Ergometer (see Figure 9). The esense electric drive support system can be integrated into other heavy mobile products. It is designed to 'feel the natural push force of the user and translate this to a smooth electric drive support' (Esense, n.d.-b). The patient lifts are either manually driven or have the esense electric drive support system pre-installed, which reduces the push and pull forces needed for a patient transfer. The ergometer is used as an ergonomic measurement tool, and can be coupled with any patient lift.

IoT can support manufacturing firms moving towards new PSS offerings (Suppatvech et al., 2019). At the time of the project, esense was conducting R&D activities to integrate IoT modules into their products, having successfully integrated them on their patient lifts (but not yet launched in the market), which allowed for data collection regarding the use of the products to be communicated remotely. Combined with the existing product portfolio, these technologies provided the foundation for the creation of a HWaaS PSS.

Figure 9. The esense product portfolio, containing the manual patient lifts (1), the e-driven patient lift (2) the esense drive kit (3), and the ergometer (4).

6.2.2 Employee Knowledge

The staff themselves, as well as their knowledge and motivations, are endogenous resources to co-creating value with customers in a service system (Lusch & Vargo, 2006; Wetter-Edman et al., 2014). By carrying out informal interviews with esense employees (incl. sales staff, product engineers, software engineers, and the commercial director), it was found that esense employees held specific knowledge with regards to physical overload prevention during the pushing, pulling, and manoeuvring of heavy healthcare equipment in healthcare (e.g. patient lifts), as well as in-depth knowledge of e-drive technologies. This was further validated later in a semi-structured interview with a healthcare technology dealer (see 6.6), who stated: "I find that the know-how, the technique and the conceptualisation of esense is at a higher level than the competitors." (Participant nr 3, from hereon referred to as P3).

» **Key insight:** The knowledge of esense employees is a key resource that can be leveraged in a PSS offering.

6.2.3 Employee Motivations

To uncover employee motivations for pursuing the HWaaS project, an informal online Co-Creative Workshop (Stickdorn et al., 2018) was held. The participants in this session included a sales representative, a software engineer, and the commercial director. The session was co-hosted with an innovation expert from Wordlenig. During the session, the answers were noted down on digital post-its in the online collaborative tool Miro (n.d.). After the co-creative session, the responses were mapped onto the 'Golden Circle' – a visual template to map the actors' and organization's motivations (Sinek, n.d.) - which helps identify the 'Why', 'What', and 'How' driving a project (see Figure 10 and Appendix D).

The employees explained that their 'Why' for pursuing this project was to help caregivers achieve safe and healthy working habits, and remain 'happy and healthy' in their profession for longer. The 'How' contained a diverse set of ideas, anchored in the core idea to use IoT-collected data to facilitate new value co-creation with customers. Moreover, the 'What' that the team envisioned was a diverse set of ideas, ranging from using IoT data collection to create a mobile application, integrating the stand-alone ergometer, and more. At this stage of the project, the intention was not to have an exact answer regarding the 'How' and 'What' of the Golden Circle, but rather to understand employee motivations, as well as to highlight the diverse perspectives that existed regarding the project to begin with.

The Golden Circle components are well-aligned with the variables in the abductive thinking equation (how + what = value), presented by Dorst (2010), which is a key aspect of Design Thinking (as described in 2.2). Thus, by bridging the Golden Circle to Design Thinking theory, a case-specific equation could be made for HWaaS at this stage:

$$\text{what?}_{\text{e.g. service}} + \text{IoT data}_{\text{and other features}} = \text{healthy working for caregivers}$$

These activities helped clarify the motivations of the caregivers, and how they influenced the project.

» **Key insight:** The motivation of esense employees played a key role in the initial framing of the project.

Figure 10. The Golden Circle (Sinek, n.d.) of HWaaS.

6.2.4 Stakeholder Map

Conducting research activities to understand the actors and resources that enable the co-creation of value is a crucial part of designing service systems (Stickdorn et al., 2018). Therefore, to investigate the complex system of actors interacting in the current system, a Stakeholder Map was co-created with esense employees in two online sessions, using the collaborative tool Miro (n.d.). The participants included an account manager, a software engineer, and a product engineer, who worked closely with the relevant technologies. The session was hosted together with an external innovation expert from Wordlenig. Based on the co-created map, the researcher distilled the information in a final visualisation, focusing on the key points of interaction, as shown in Figure 11.

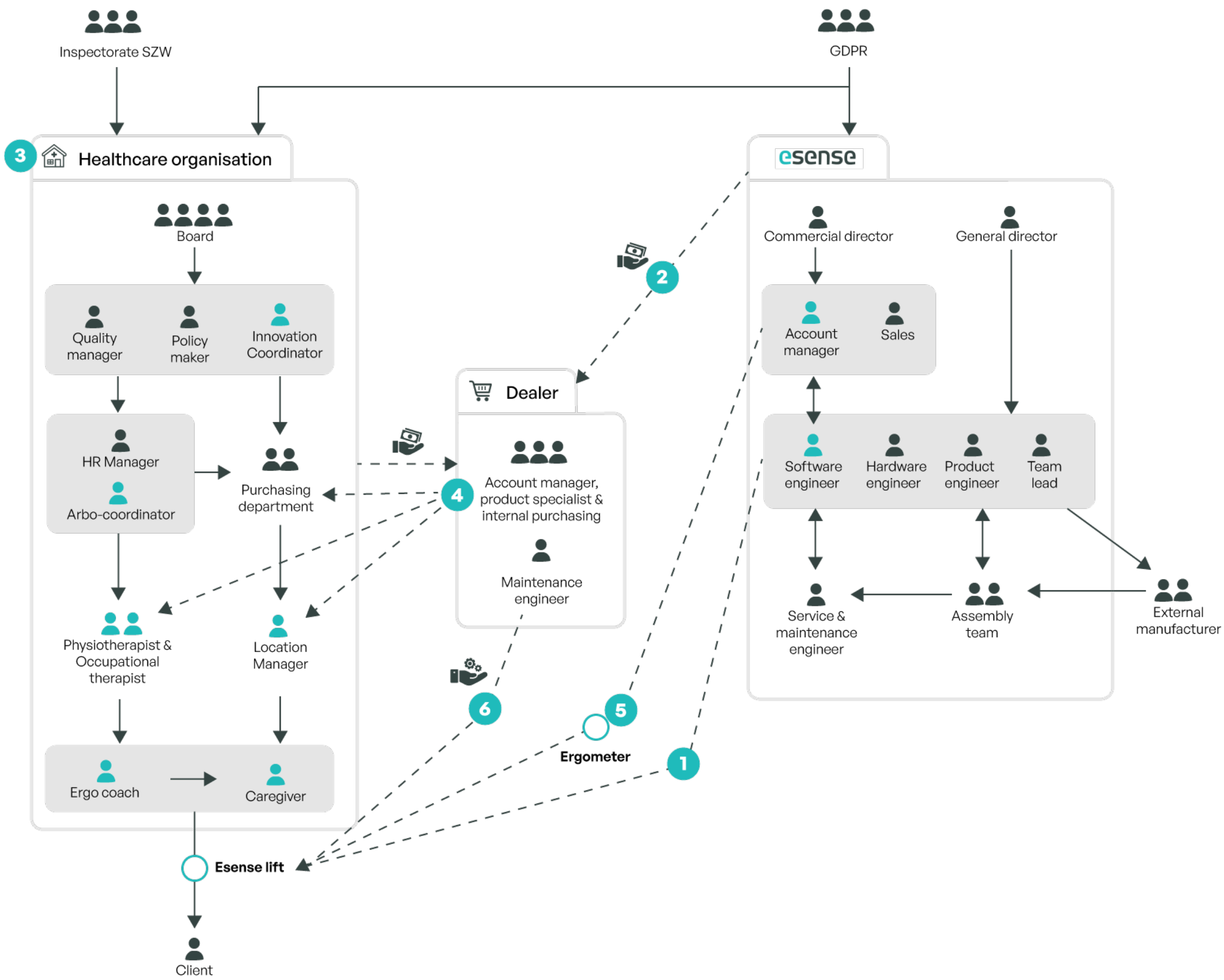

Figure 11. Co-creating a stakeholder map with esense employees proved an effective way to obtain an initial idea of the complex system for which a PSS was to be designed.

There are three main organizations involved in the current delivery system of the esense healthy working technologies: esense, the dealer, and the customer (healthcare organisations). Additionally, governmental bodies play a part in regulating the healthcare system. Below, some of the key interaction moments in the shared space between the organisations are described, referencing the numbered steps in Figure 11.

1. Esense (and Indes BV) design and assemble the patient lifts.

2. The sale of patient lifts occurs through the dealer, who has a long-term contract with healthcare organizations to supply them with healthcare devices and services.

3. The typical customers of patient lifts are nursing homes. However, since the internal structure varies between organisations, it is difficult to generalize healthcare organisation's internal structures. Figure 11 models a simplified archetype of a nursing home. A more in-depth discussion regarding the key actors and processes of healthcare organisations can be found in 6.4.

4. Healthcare organisations replace their patient lifts every 5 - 10 years. The purchasing of a patient lift happens in collaboration with an account manager from the dealer and either one or multiple actors from within the healthcare department. This can be the location manger, a physiotherapist, an occupational therapist, or the purchasing department.

5. In some cases, an esense Account Manager participates in the sale process and collaborates with the dealer to conduct an ergo measurement test at a healthcare location. In these scenarios, the ergometer is used to allow the customer to compare the forces exerted when using different patient lifts, since the device can be mounted on any lift.

6. The dealer is contracted to carry out maintenance for the healthcare organisation, to ensure that the patient lift is safe to use.

» Key insight: Co-creating a stakeholder map with esense employees proved to be an effective way to visualize the complex system which esense operates within.

6.2.5 Current BM

To obtain a working understanding of the current BM implemented by esense, the BM Canvas (Osterwalder & Pigneur, 2010) was utilized (see Appendix E1). The BM Canvas consists of nine main building blocks: customer segments, value proposition, channels, customer relationships, revenue stream, key resources, key activities, key partnerships, and cost structure. The current BM for esense is based on the one-off sale (revenue stream) of their patient lifts, through external dealers (key partners, channels, customer relationship), to healthcare organizations. The target group for the patient lifts largely consists of nursing homes, elderly homes, and care facilities for people with disabilities (customer segment). Esense strives to remain human-centered by involving key stakeholders in the design process (key activities) and has a set of high-quality products in their portfolio and skilled staff (key resources). Their costs consist of both variable costs and fixed costs, associated with R&D, salaries, production, and more (cost structure). The value proposition consists of the sale of manual or e-driven patient lifts, which are accurate, light to push and pull, high-quality and easy to manouver (vale proposition). The built-in ergo measurement system provides live feedback to help the users adjust their movement.

The BM Canvas was reviewed by the researcher, with support from an innovation expert from Wordlenig, identifying several weaknesses and opportunities that could be addressed in a new servitized BM (Appendix E2).

» **Key insight:** The BM Canvas revealed multiple opportunities that can be addressed in a new IoT-enabled servitized BM, including: unobtrusive ergonomic data collection that is easier to access than using the ergometer, creating recurring revenue streams, creating closer relationships with the customers, and strengthening esense's position in the market as an innovative company.

6.2.6 Customer Journey

When purchasing a patient lift, customers go through a customer journey with esense and the dealer. To understand this journey better, a co-creative customer journey mapping session was hosted online, together with the Account Manager from esense (see Figure 12). The journey map was created using the online tool Miro (n.d.). Insight was also used from the interview sessions with the key stakeholders (see 6.4).

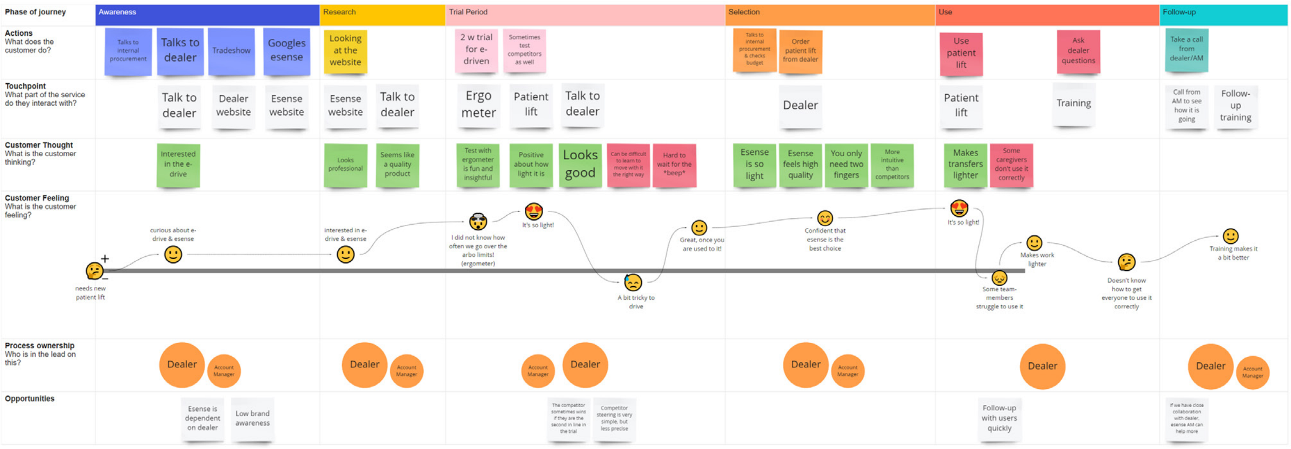

Figure 12. Current customer journey when purchasing an e-driven esense patient lift.

The customer journey begins with the customer and the dealer discussing the options and considerations for the next patient lift. In this moment the dealer can create awareness of the e-driven alternative and generate interest by explaining the benefits of relieving the customer of physical overload. The customer may then elect to begin a trial with e.g. two different brands, for two weeks each. At the beginning of the trial, an ergo measurement test may be carried out, often by the an esense sales representative, in collaboration with the dealer.

During the trial with esense, the caregiver may experience some frustrations with learning to work with the e-driven lift. Once this period is up, the decision making unit (e.g. the location manager) makes the order, potentially in collaboration with a central purchasing department within the healthcare organization. The choice is largely based on the experiences of the team, i.e. if the team had negative experiences with an e-driven lift, it is unlikely to be purchased. However, if the caregivers experience the benefit of the e-driven lift, "they almost always choose esense", as described by P3 (dealer) in the stakeholder interview (see 6.4). These benefits are often the fact that the e-sense is so light, can be maneuvered with only one finger, is beautifully designed, and intuitive. Next, the lift is delivered to the location, and instructions are given on how to work with it. However, caregivers may still struggle to make use of it correctly. Therefore, follow-up calls are ideally done by the dealer, or the esense account manager, but this does not always happen.

By creating and analysing the customer journey, several weaknesses and opportunities were identified, highlighted in Appendix F.

» Key insight: Creating a customer journey map of the purchasing of patient lifts helped form an understanding of the current process, and identify gaps that could be addressed in a new IoT-enables PSS.

6.3 The Healthcare Organization

Healthcare organizations are complex systems, consisting of autonomous actors, whose behaviors influence each other, and whose actions may not always be fully predictable (Plsek, 2003). To obtain this insight for the context of esense customers, desk research, stakeholder mapping with esense employees (see 6.2), and semi-structured interviews were conducted with members of the healthcare organization (see 6.4). To provide the reader with an overview of the research, the internal stakeholder map is first explained, as shown in the next section.

6.3.1 Nursing Home Stakeholder Map

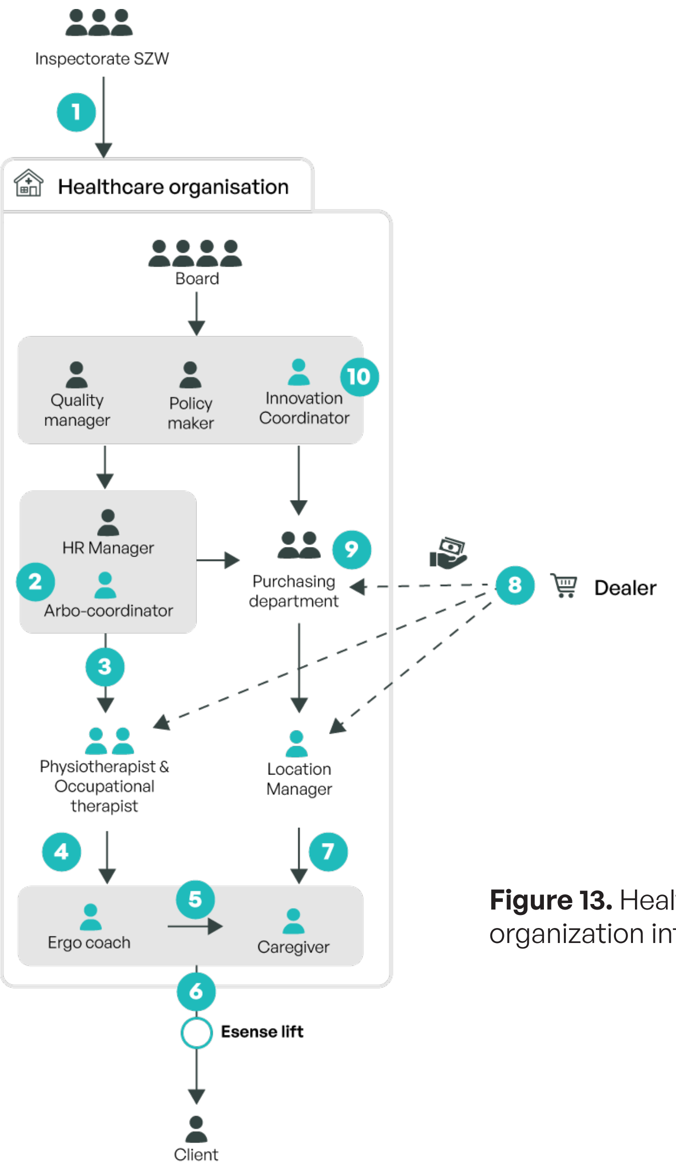

Figure 13. Healthcare organization internal structure.

Healthcare organizations typically consist of several different care locations, and a large network of actors, that collaborate to ensure quality care for the patients and improve the working conditions of caregivers. Following the numbered steps in Figure 13:

1. The Inspectorate SZW is the governmental body that regulates occupational health and safety in the Netherlands (for more information, see 4.3).

2. The person responsible for ensuring that health and safety standards are followed in the organisation is the 'Arbo-Coordinator', who develops policy to prevent physical overload in the organisation and trains the physiotherapists and occupational therapists.

3. The physiotherapist and occupational therapists help protect employee health and provide advice for how caregivers work in a healthy way. They also train the ergo coaches in how to use available tools, e.g. patient lifts.

4. The ergo coaches are caregivers who have additional training in ergonomics. Usually, in every team of caregivers, there is at least one ergo coach.

5. The ergo coaches helps teach and instruct the caregivers how to use available devices in a healthy way, and observce them at work to give advice regarding posture and ergonomics.

6. Both ergo coaches and caregivers use patient lifts to transfer their clients e.g. from the bed to the shower.

7. The location manager strives to ensure that there are enough staff and patient lifts available to care for their clients, and manages the location budget.

8. Either the location manager, a physiotherapist or occupational therapist, or the purchasing department will collaborate with the dealer to purchase devices and equipment. Patient lifts are typically replaced every 5-10 years.

9. Most healthcare organisations have a centralized purchasing department, which either advises or instructs the individual locations what devices to purchase.

10. The innovation coordinator only exists in some healthcare organisations. This person is responsible for exploring what technology trends in the market, and may arrange for the organisation to partake in pilot tests with new technologies.

» Key insight: Healthcare organisations have a complex internal structure. Creating a stakeholder map helped clarify the interactions and key stakeholders.

6.3.2 Key Stakeholders

To increase the chances of new technology being accepted by this complex network, service providers and manufacturers should proactively strive to understand this system and identify key thought leaders who stimulate innovation adoption (Plsek, 2003). To summarize the experiences of the key stakeholders identified in the healthcare organisation (being the caregiver, ergo coach, physio- and occupational therapists, arbo coordinator, and the location manager) Empathy Maps and Personas were created (see Appendix G). These tools helped create a deeper understanding of the customers. Below, short descriptions of these key stakeholders are included, based on the primary research gathered in Stakeholder Interviews (see 6.4), the Empathy Maps & Personas, as well as Desk Research.

Caregiver. Within a nursing home facility, caregivers tend to the daily needs of the clients. The caregivers are managing several tasks, including caring for the patients, informing client family members, collaborating with a range of healthcare professionals, as well as transporting the patients who have limited mobility, either using an active or passive patient lift. Caregivers in the Netherlands can hold different levels of certification: (1) licensed practical nurses (verzorgende IG) and (2) BIG-registered nurses (verpleegkundige) (NCOI, 2017). BIG-registered nurses hold a higher degree than licensed practical nurses and are allowed to perform more complex nursing procedures. (Registering as a healthcare professional, 2021). However, since both types preform similar caregiving activities for the client (NCOI, 2017), they are, in this project, both referred to as caregivers. The interviews with the healthcare organisations highlighted that caregivers are under a lot of pressure, and are often in a rush, which sometimes causes them to use the available patient lifts incorrectly. Moreover, the healthcare worker has no actual insight into the physical load they experience. To summarize the experiences of a caregiver, an empathy map and persona was created (see Appendix G1 & G2).

Ergo Coaches. Ergo coaches are caregivers that have taken on additional training and responsibilities over developing and encouraging ergonomic working habits in their team (Knibbe et al., 2007). Similarly to caregivers, ergo coaches experience high physical load in their profession. Ergo coaches, however, also have the additional responsibility to observe and coach the caregivers to use tools correctly and build healthy working habits. When ergo coaches observe issues, they may also report this to the occupational therapists and physiotherapists, to receive additional support and advice. Although ergo coaches strive to give their best support to the team, managing both ergonomic and patient-care responsibilities can be challenging. Moreover, some caregivers are especially difficult to coach. To summarize the experiences of an ergo coach, an empathy map and persona was created (see Appendix G3 & G4).

Occupational- & Physiotherapists. These are staff hired to promote healthy working (ergonomics). Working as an occupational therapist requires a four year HBO diploma (Opleiding Ergotherapie, n.d.). Occupational therapists and physiotherapists work in healthcare locations to promote the health and mobility of both patients and caregivers. They are often the employees tasked with educating the team on how to use the available tools in a safe and healthy way. Moreover, occupational- and physiotherapists sometimes have limited insights into their teams, as they often work in multiple teams and locations. To summarize the experiences of an occupational therapist, a persona and empathy map was created (see Appendix G5 & G6).

Arbo-Coordinator. Arbo-Coordinators ensure that physical overload is prevented in a healthcare organisation. They ensure that the organisation follows regulation regarding occupational health and safety, and strives to measure, evaluate, and improve the working conditions in the organisation. The Arbo-Coordinator develops policies and training for the entire organisation. However, the Arbo-Coordinator has limited insight into the locations and relies on hearing about issues on the work-floor through a network of occupational- and physiotherapists, and ergo coaches. Moreover, she has no way of knowing the physical overload that her team experiences, and therefore often hears about a problem when it has developed into a physical complaint. To summarize the experiences of an Arbo-Coordinator, an empathy map and persona was created (see Appendix G7 & G8).

Location managers. Location Managers have a leadership role within the healthcare location, directing and supervising the teams, departments and employees (Ik Zorg - Meya Leidinggevende, n.d.; Zorgmanager, n.d.). Oftentimes, employees who have worked for long in the organisation, such as caregivers, can grow into the role of a manager, with additional courses and leadership capabilities. The location manager strives to ensure high quality care within the facility, and that the clients are well taken care of. Moreover, the manager also has the responsibilities of making sure that the staff has the necessary tools and devices they need to carry out their job (Zorgmanager, n.d.). Location managers often play a key role in the procurement of new patient lifts, overseeing the finances of the location, as well as ensuring that there is enough staff available to care for the clients. It is therefore highly important for the location managers to bring the sickness absence down. To summarize the experiences of a location manager, an empathy map and persona was created (see Appendix G9 & G10).

» **Key insight:** Using Empathy Maps and Personas proved to be effective tools to map the insights from stakeholder interviews, and to build a better understanding of stakeholder needs, wishes, and challenges.

6.4 Stakeholder Interviews

To empathize with the key external stakeholders identified in the stakeholder mapping exercise, semi-structured, in-depth interviews were conducted (Stickdorn et al., 2018). This section describes the steps taken to gather and analyse the data. In the sub-sequent sections, the outcomes of the interviews are detailed, in the form of detailed descriptions of key actors, as well as key emerging themes that emerged through the analysis.

6.4.1 Recruitment

Recruiting participants from the healthcare context proved to be a difficult task, since the COVID-19 pandemic had placed increased pressure on the healthcare system in 2021, especially in elderly care (Data Europe, 2020). Moreover, the interviews needed to be held online, to comply with national regulations regarding social distancing, and therefore relied on participants having enough time and technological skill to participate. In total, 11 individuals participated in the interviews (see Appendix H for the anonymized participant list), recruited with the help of a sales representative from esense, who made the initial recruitment phone calls. Out of the 11 participants, 9 worked within healthcare organizations as caregivers, ergo coaches, physiotherapists or occupational therapists, Arbo-Coordinators, innovation coordinators, or HR advisors for sustainable employability with previous responsibilities as a location manager. 2 participants worked in dealer organizations, gathering the perspectives of 1 account manager, and 1 ergonomic advisor with additional sales responsibilities.

6.4.2 Protocol

The interviews were conducted online, to follow COVID-19 guidelines, and was guided by open-ended research questions. The interviews began by obtaining verbal consent from the participant to collect the data, as well as to record the conversations. The sessions lasted 60 minutes each, were co-hosted by an innovation expert from Wordlenig, and was held individually with the participants. The first 50 minutes of each session were used to ask exploratory questions regarding the individual, their role and their experiences with physical overload and the use of patient lifts. In the last 10 minutes, a small teaser regarding the HWaaS project was given, i.e. the idea to collected data remotely and invisibly from the patient lifts (using IoT) to measure and monitor the physical load that occurs on the work floor. This was done to gather the participants immediate responses to the project.

6.4.3 Analysis

After the interviews had been held, the data was anonymized, and transcribed. Next, the findings were analysed by creating an affinity diagram (Baxter et al., 2015). Affinity diagrams help researchers analyse rich qualitative data by grouping (digital) sticky-note and identifying emergent themes. This activity was carried out using the digital tool Miro (n.d.), by creating a sticky-note containing the researcher's shortened interpretation of key points made by the participants. The affinity diagrams are presented in Appendix I-1. From the analysis, several key insights (or themes) emerged (see 6.4.4). To map the problems, needs, and experiences of the key stakeholders interviewed, empathy maps were created, which then informed personas, as shown in Appendix G.

6.4.4 Results from the Interview

To analyse the stakeholder interviews, an affinity diagram was created (see Appendix I-1). From the affinity diagram, several key insights were derived. These findings have been summarized in Table 5 and are detailed on the following pages, with the tallied responses gathered in Appendix I-2.

Table 5. Key insights from user interviews. The evidence strength is based on the number of participants that mentioned the issue, and the attention that they placed on the subject.

	Insight	**Evidence Strength**
1	Patient transfer is a cause of physical overload in healthcare, but it is not possible to say exactly how much.	+++
2	Caregivers need to adopt healthy behaviours with the patient lifts, but behaviour can be hard to change.	+++
3	The healthcare industry is slow at adopting e-driven lifts.	+++
4	There is currently no objective way to measure the physical load their teams are experiencing.	+++
5	Healthcare organisation's often do not have a clear strategy for physical overload prevention and sustainable employability.	+++
6	The pressure placed on caregivers is high and increasing.	+++
7	Ergonomic professionals seek knowledge sharing opportunities & best practices.	+++
8	The procurement process of healthcare innovation is complex and differs between organisations.	+++
9	Although the healthcare industry is slow at adopting technology, they are increasingly interested.	+++
10	The ergometer is insightful, but too complicated in practice.	++
11	Esense is a trailblazer, but with low brand awareness.	++
12	Healthcare organisations find the idea of collecting data promising, but data is not everything, and privacy could be an issue.	+++

Insight 1: Patient transfer is a cause of physical overload in Healthcare, but it is not possible to say exactly how much.

Acknowledged by virtually all participants, physical overload in the healthcare sector is a considerable problem, causing long-term illness in caregivers, as well as being costly for healthcare organisations. Some of the commonly mentioned physical complaints experienced by caregivers were shoulder, back, elbow, knee and hands. The heavy work was found to is a contributor to caregivers deciding to leave their profession: "... we talk about how we won't do this until we are 60, because of the heavy work and stress." (P8). Most of the participants identified patient transfer as a contributor to physical overload, due to high pushing, pulling, manoeuvring forces, and incorrect posture. As expressed by P6: "The most common issues are regarding extreme posture, pushing and pulling". P2 estimated that 60-70% of physical complaints were caused by the incorrect use of patient lifts, in one of her departments.

Many of the participants had witnessed caregivers using patient lifts incorrectly on the work floor, leading to physical overload. One reason was that many departments still used manual lifts, which required higher push and pull forces than e-driven alternatives. Moreover, for those using e-driven lifts, caregivers often failed to wait the 1 second it takes for the e-drive to activate, leading to unnecessary physical load. P11 states: "We have the e-driven patient lift from esense [...] The issue is to get caregivers to hold onto the knowledge of how to use tools correctly, which is really complicated". However, the participants expressed that it was not possible to say to which extent sickness absence can be attributed to incorrect patient lift use, due to the complex interwoven factors, as well as the lack of insight into reasons for sickness absence (protected by privacy laws). Nonetheless, the interview results suggested that preventing physical overload during patient transfer, and teaching caregivers how to work with the e-driven patient lift, could have a positive impact on caregiver health.

Insight 2: Caregivers need to adopt healthy behaviours with the patient lifts, but behavior can be hard to change.

Participants explained that caregivers often struggle to adopt the ideal use of the patient lifts. Changing their behaviour is in some cases proving to be a very difficult pursuit, as described by P1: "That is just how [people] are – we need a 6 month period every time we have to change". P9 mentions: "People need to go through a behavioural change in process. I notice now that when I have the day off, they fall into their old behaviour when I am not looking. Having a culture of communication is really important at this moment." Moreover, participants described several influencing factors for why some caregivers struggled to adopt the correct behaviour for using the patient lifts, including: (1) older staff being reluctant to change because they are used to the 'old ways of doing things', (2) younger staff overestimating their ability to perform heavy movements, as they do not yet experience the consequences of long-term exposure to physical overload, (3) team or personal attitude (stubbornness vs. being open to change), (4) complex situations, and most of all: (5) stress.

Insight 3: The Healthcare Industry is Slow at Adopting E-driven Lifts

Stakeholders described an almost unanimous picture, which manual lifts are still the norm, even though they require more physical demand of caregivers than an e-driven equivalent. P3, a healthcare technology dealer, described: "I see a growing market for electric driven patient lifts. I think it is happening too slowly, considering the big impact of the electric driven patient lifts." There are multiple reasons for why manual lifts remain the norm: (1) e-driven take time to get used to working with and some caregivers reject this new way of working, (2) e-driven lifts are typically more expensive, (3) patient lifts are typically bought as replacement purchases after 10 years of use, and if e-driven is not mentioned as a requirement in the purchasing process, it may not be considered. For these reasons, caregivers are experiencing unnecessary physical load in their day-to-day activities.

One of the most common scenarios described for why e-driven patient lifts had been rejected by healthcare organisations, was that for some caregivers, learning to work with e-driven lifts takes time. Moreover, when using e-driven patient lifts, it takes a second for the system to activate, meaning that the caregiver should count to three and then gently start pushing. When done right, a patient transfer can be done using only one finger on the lift. However, many caregivers are used to their old way of working, which may lead them to quickly grab and push or pull the machine, which has a delayed response. Unfortunately, some teams simply reject this new way of working, leading to healthcare organisations re-ordering a manual lift instead. P3 (healthcare technology dealer) described: "It is very difficult to motivate them to try new technology that can help them and their team".

However, the healthcare sector's interest in e-driven patient lifts is increasing. As P3 states, "E-driven is the future!". One of the interviewed locations had committed to switching over completely to e-driven moving forward. Additionally, many caregivers like working with e-driven technology, e.g. P4: “[The Caregivers] like them! We use them in the departments that sometimes have carpets, which are easier to manoeuvre with e-drive. [...] When we buy a new one, we want an electric”. Similarly, P9 describes: “once you know how to use the elevator, [caregivers] see how it reduces physical load, and say that the elevator is simply a super invention!”.

Insight 4: There is currently no objective way to measure the physical load their teams are experiencing.

Although physical overload is a threat to employee health, at this point in time, the healthcare organisations had no objective way of measuring the actual physical load experienced by the caregivers on the work floor. Instead, the ergo coaches, occupational therapists and physiotherapists observe caregivers, and intervene when they notice unhealthy movements. However, since these ergonomic professionals are also busy taking care of patients, as well as performing administrative tasks, they are not able to always see what happens on the work floor. Therefore, caregivers need to take responsibility of their own health, and report to their team ergo coach if they detect any physical complaints. Moreover, multiple participants explained that caregivers often behaved differently when they were not being observed by the ergo coaches, often falling back into unhealthier patterns.

Healthcare organisations also make use of employee satisfaction surveys to identify areas of improvement and monitor how they are performing in aspects related to sustainable employability. However, the results from these surveys rely on self-reporting, making it difficult to create an accurate picture of the physical load experienced by caregivers. Moreover, other data that is tracked with regards to sustainable employability were the number of sickness days recorded and the number of trainings given over the year. Following this practice, healthcare organisations often end up with a reactive and subjective approach to reducing physical overload, as the point where a caregiver is experiencing complaints is already a step too late.

Lastly, healthcare organisations make use of more objective tools such as the ‘TillThermometer’ – an online tool that approximates the severity of physical load that caregivers experience in practice, based on a certain parameters like the number of transfers the team is doing, how mobile the patients are, and more (TilThermometer, 2021). This indicates that healthcare organisations have an interest in more objective forms of measuring physical overload.

Insight 5: Healthcare organisations often do not have a clear strategy for physical overload prevention and sustainable employability.

Most of the healthcare professionals interviewed in this research described lacking strategies towards physical overload prevention and sustainable employability. In many cases, the prevention approach described was done in an 'ad-hoc' way, relying on subjective information. Furthermore, some organisations had undergone recent mergers, which had led to unclear internal processes: "We recently went through a merger between three organisations that became one. Right now it is a bit chaotic" (P2). Additionally, other organisations turned to the overall strategy of their branch union, as physical overload was not yet a part of their own internal strategy: "In the whole, the whole sector [physical overload prevention] is a focus point. And also, for our organization is important, but we are not as far as we want to be" (P7). Two of the interviewed organisations did, however, have a more clearly formed strategic focus on sustainable employability, making investments in technologies that reduce the physical load of workers, and stating that sustainable employability was an important part of the internal organisational vision.

Meanwhile, sustainable employability is becoming an increasingly pressing issue, making more healthcare organisation interested in the topic. Healthcare organisations need to offer more attractive work environments to their employees, to retain and recruit caregivers. However, even though there is increasing attention placed on the working conditions in healthcare, many organisations still neglect taking action to promote sustainable employability and physical overload reduction. As P5 described it: "I think what you see is that many organisations are talking the talk, but not by definition walking the walk [...] In the back of their mind [healthcare organisations] know that they have to do something about sustainable employability, but it is not made the main priority of any organisation.". It became evident through the interviews that, although healthcare organisation wish to put sustainable employability on the agenda, this is difficult to achieve, since other issues in the organisation are often more pressing.

Lastly, multiple participants highlighted that the topic of 'healthy working' has both a mental and physical component. Thus, reducing physical overload is not the only pressing issue in terms of reaching more sustainable working conditions for caregivers. Furthermore, both physical and mental health was negatively affected by the COVID-19 pandemic in 2020 and 2021. One participant explained that, although physical overload is an important topic in their organisation, the priority at the time of the project was managing the psychological aftermath of the pandemic.

Insight 6: The pressure placed on caregivers is high and increasing.

Participants emphasised that caregivers are under a lot of pressure in the workplace, due to an aging workforce, aging patients with increasingly complex care needs, high administrative loads, an increasing need to understand how to use technology, and more. This means that caregivers are often feeling like they need to rush during their workday, to complete all the tasks that are expected of them. Moreover, sickness absence is a common occurrence in the organisations interviewed in this project, also reducing the number of available staff members. Meanwhile, ergo coaches, physio therapists and occupational therapists have responsibilities both towards employee health, as well as the caring for the patients. This adds another layer of workload on these professionals, where ergo coaches often need to prioritize the health of their patients above their own needs. When healthcare was faced with the COVID-19 pandemic, the pressure on healthcare workers further increased. Therefore, healthcare organisations are always looking for solutions that can reduce the workload of their employees.

Insight 7: Ergonomic professionals seek knowledge sharing opportunities & best practices.

Within healthcare organisations, actors often seek opportunities to learn from one another to reduce physical overload and facilitate sustainable employability. This comes in the form of internal working groups for physical overload (often consisting of ergo coaches, physiotherapists, and occupational therapists), internal newsletter about ergonomics and innovation, periodical internal meetings within the organisation about physical overload prevention, as well as the formal and informal knowledge sharing with other healthcare organisations within their network (e.g. employers associations, insurance networking events, innovation networks, and more).

Insight 8: The procurement process of healthcare innovation is complex and differs between organisations.

When speaking to healthcare organisations and dealers, it became evident that the procurement process is complex, and differs between organisations. Healthcare organisations typically have a mixture between a centralized and decentralized approach to purchasing healthcare innovation. For some technological purchases, like that of a patient lifts, most healthcare organisations have a standardized process, where either a location has its own budget and autonomy to choose a patient lift (following a list of requirements), or the location is guided by a centralized purchasing committee to select a certain product or choose from a few brands. Typically, the list of requirements and the offered brands dictate which patient lift the location ends up ordering. This list of requirements, as well as the budget, is typically based on the previous patient lift. Thus, for a location to be able to choose an e-driven lift, it must have been made a priority at the beginning of the purchasing process. Here, the dealer plays a big role in influencing the healthcare organisation to consider e-driven.

Moreover, participants explained that purchasing new innovation can sometimes be more complex, since there may not be assigned budgets for these devices. Moreover, most healthcare organisations do not have a budget specifically for sustainable employability innovation. This makes it difficult for some healthcare organisations to imagine a straight-forward way of purchasing these technologies, including the proposed HWaaS concept. However, healthcare organisations that have a strong financial profile and make sustainable employability a priority, explained that they can arrange their budget to invest in innovation they find promising. Moreover, several investment programs and networks exist to help healthcare organisations invest in pilot projects. Additionally, individual locations have their own budget which, to a certain extent, they can spend as they choose.

Insight 9: Although the healthcare industry is slow at adopting new technology, they are increasingly interested.

The participants explained that their healthcare organizations often struggle to adopt new technology. Some employees and locations are more resistant than others. In order for healthcare technology to be adopted by a healthcare organisations, it must fit into the organisation's way of working, and not demand too much of the healthcare workers. Ideally, healthcare innovation should relieve the caregivers of some workload. In general, nursing home facilities (intramurale zorg) are more receptive to new technology than at-home care, as they have bigger budgets. Moreover, many healthcare organisations participate in pilot tests to test out new technologies.

Insight 10: The ergometer is insightful, but too complicated in practice.

Some of the participants had used the ergometer, and had mainly positive experiences with it. They explained that the measurements helped create insight and awareness amongst the caregivers, and that they wanted to use it again. However, one location who had been given the ergometer independently, without in-person instruction, had had a disappointing experience where the technology was too complicated. Similarly, a participant explained that they thought the ergometer created important insight, but that they did not know how to use it independently. Additionally, it was expressed that the ergometer only gives a snapshot measurement, but to obtain a real idea of the physical demand placed on caregivers, you need to collect long-term data with all your team members. Lastily, receiving the full ergo measurement report in the current process takes several days (although an initial report can be made during the experiment. This information combined a gap in the current ergonomic measurement journey that could be bridged using remote and embedded data collection.

Insight 11: Esense is a trailblazer, but with low brand awareness.

Through the conversations, it became evident that those who knew about esense had positive connotations with the brand. The patient lifts were seen as high quality, intuitive, and the brand as having a better 'know-how' of healthy working than many competitors. Moreover, the collection and interpetation of data to reduce physical overload were seen as innovative part of esenes. However, some of the participants knew little about the brand. This suggested that esense has an opportunity to expand their brand awareness within the target market.

Insight 12: Healthcare organisations find the idea of collecting data promising, but data is not everything, and privacy could be an issue.

When the participants were interviewed about the potential of remote data collection regarding the physical load experienced by caregivers when using the patient lifts, most responded positively. Ergo coaches liked the idea of being able to review information about the teams when they were not ablet to observe them in person. Moreover, they seemed intrigued by the idea to access the data in real time, since the ergo meter would take several days before the complete report was produced. However, the participants also had some reservations, mainly with regards data privacy and data overload. Lastly, participants highlighted that data is not always enough to create sustainable behaviour change.

Thus, the insights gathered in the Discover phase, through the Desk Research, Stakeholder Mapping, as well as the Stakeholder Interviews provided important insight for the continued development of the HWaaS project. The qualitative data was rich in nature and added to a better understanding of the Service System and actors for which the HWaaS would need to fit into. Next, the researcher began converging this rich data into reformulated problem statement, as introduced in Chapter 7 – Define.

7. Define

The second phase of the Triple Diamond Design Process is 'Define'. This phase evaluated the initially posed 'Riskiest assumptions' (7.1), framed the problem based on the generated insights (7.2), as well as identified opportunities (7.3) for the ideation phase.

7.1 Reviewing the 'Riskiest Assumptions'

As established in the project brief in the beginning of Part D of this reprot, an Assumption Map was created at the early stages of the research phase to articulate the 'riskiest assumptions' underlying the HWaaS project. Gothelf and Seiden (2021) state that "Declaring your assumptions allows your team to create a common starting point" (p. 23). The stakeholder interviews had been guided by these initial assumptions, with the goal of validating them or refute them, as well a to gain additional insight into the problem space. As shown in Table 6, the assumptions were evaluated based on the strength of the evidence from the qualitative research (semi-structured interviews, se tallied feedback in Appendix I-2) and literature review (chapter 4). Assumptions 1, 2, 5, and 6 had, at this point in time, strong evidence in their favour. This indicated that the initial assumptions seemed to be rather well-aligned with the feedback from the stakeholders.

Two of the initial riskiest assumptions could not be confirmed (Assumption 3 and 4, Table 6), and in fact, evidence had been found against them. Firstly, based on the feedback from the dealers present in the interview, they had little interest in receiving remote data regarding the maintenance status of the patient lift. This could be explained partially by the fact that only two dealers had been included in the research, and that the participating dealers had outsourced the maintenance to other parties. Moreover, the low involvement of dealers in the project related back to the original motivation for pursuing the HWaaS project: the briefing was clearly focused on leveraging IoT to create new value for healthcare organisation in tackling physical overload, which automatically switched the focus away from, e.g. using the IoT-data for predictive maintenance service solutions. Therefore, at this point in the project, it was decided that the scope would focus purely on co-creating value with the healthcare organisations in preventing physical overload, and not improving the maintenance process of the dealers. This could however be an interesting aspect for esense to explore in future research.

Table 6. Evaluation of the initial 'riskiest' assumptions that were identified in the beginning of the 'Healthy working as a service' research project.
+++ = Strong positive indication, - = Negative indication, ? = Not yet investigated.

	Initial Riskiest Assumptions	Evaluation
1	Physical overload caused by the incorrect use of patient lifts leads to physical complaints and sickness absence in caregivers.	+++
2	Healthcare organisations are interested in receiving objective data collected by the patient lifts (using IoT) to gain measure and monitor the physical load that occurs on the work floor.	+++
3	Dealers are interested in receiving remote data regarding the status of the patient lifts, to trouble-shoot and conduct more efficient maintenance.	-
4	Esense can build a simple business-case by calculating the ROI from the use of HWaaS in reducing sickness absence.	-
5	Healthcare organisations are interested in the HWaaS concept and value proposition.	?
6	Esense can build a desirable, feasible, and viable IoT-enabled business model around the HWaaS project.	?

Moreover, the second assumption that received a negative evaluation was assumption 4 (Table 6), which hypothesized that esense could build a simple business-case by calculating the ROI for using HWaaS to reduce sickness absence. This assumption could not be validated since, at the time of this project, insufficient research had been done to prove the effectiveness of the solution in reducing costs associated with sickness absence. Therefore, it would be difficult for esense to make this type of promise to their customer. Based on this analysis, it was decided that HWaaS would not strive to make this type of promise to the customer, but rather focus on the potential added value IoT could have in improving internal processes for physical overload prevention. This was deemed as more suitable, since most participants expressed that helping caregivers use the available devices correctly could have a positive impact on employee health.

Based on these assumptions, an updated list was summarized (see Table 7), combined with the additional insights that were derived throughout the research.

Table 7. Updated 'Riskiest Assumptions', based on the stakeholder interviews and literature reviews. + = Positive indication, - = Negative indication, ? = Not yet investigated.

	Updated Riskiest Assumptions	Evaluation
1	Physical overload caused by the incorrect use of patient lifts leads to physical complaints and sickness absence in caregivers, but it is currently impossible the exact extent.	+++
2	Healthcare organisations are interested in receiving objective data collected by the patient lifts (using IoT) to measure and monitor the physical load that occurs on the work floor, but data is not everything, and privacy could be an issue.	+++
3	Esense can build a desirable, feasible, and viable IoT-enabled BM around the HWaaS project.	?
4	There is not enough evidence for the effectiveness of e-driven to reduce sickness absence at this point in time to make promises regarding ROI, however, healthcare organisations find the HWaaS value proposition attractive enough to be interested.	?
5	A PSS can be designed around the esense products and technologies that is desirable for the customers.	?

» Key takeaway: The updated riskiest assumptions would serve as inspiration for the exploration of the solutions space (Chapter 8), and later be validated or rejected in fourth phase of the Triple Diamond Design Process – Validate (Chapter 9).

7.2 Framing the Problem

Caregivers conducting patient transfer using floor-driven patient lifts experience physical overload and complaints, associated either with the use of a manual lift, or the incorrect use of e-driven patient lifts. Moreover, thre is a need to investigate the strength of the correlation between physical overload during patient transfer, and sickness absence, to better protect caregiver health. Even though there exist several employees within the healthcare location (ergo coach, occupational therapists, and physiotherapists) that continuously train caregivers to use the tools correctly, several factors, including high work pressure and difficulty in adopting new behaviour, makes this process difficult to control and manage.

Moreover, healthcare organisations have no way of unobtrusively measuring and monitoring the physical load that occurs on the work-floor in practice. This lack of insight makes it more difficult for caregivers to avoid exerting forces that exceed recommended healthy limits – they are fighting an invisible enemy, being physical overload. Moreover, this means that it is difficult for organisations to fully grasp their internal issue of physical overload, and often rely on information traveling via word-of-mouth from the work floor to higher management. Moreover, although the ergometer allows healthcare organisations to measure the physical load that occurs in a transfer moment, the test is carried out under experiment-like conditions, which does not necessarily give an accurate representation of the physical load that occurs on a day-to-day basis. Therefore, a continuous, objective, and unobtrusive way to monitor physical overload is needed in the healthcare context.

7.3 Opportunities

Through stakeholder involvement, the research conducted in the Discover and Define phase illustrates a positive indication from the customers that using objective data regarding pushing and pulling forces could be valuable for healthcare organisations to monitor, to improve their prevention strategy. In this context, embedded IoT data collection offers a potential platform for value co-creation with healthcare organisations. Moreover, it was found that healthcare organisations are interested in learning best practices associated with patient transfer, to make better use of the available tools and become more efficient in their work. This suggests another dimension that could be addressed in the HWaaS PSS.

By analyzing the existing customer journey and BM, it was found that adopting IoT-enabled servitization models could create new revenue streams, and deliver new value to customers in the market, help esense create a stronger bond with their customers, and enhance brand awareness in the target market. Moreover, some 'innovator' healthcare organisations are increasingly taking steps to promote sustainable employability to retain and attract talent, and are ahead of the rest of the market. These organisations could be especially interesting for esense to target in the HWaaS project as early adopters.

8. Ideate

The third phase of the Triple Diamond Design Process contains research activities focused on imagining the future service provision (e.g. Value Proposition, BM, Concept and Interactions) that could solve the established problem definition. These activities included defining a Value Proposition (8.1), identifying an appropriate IoT-Enabled Servitized BM (8.2), carrying out Ideation moments with esense employees (8.3), arriving at a final Idea Selection (8.4).

8.1 Value Proposition

Its understood in S-D Logic that a firm cannot create value ***for*** a customer, but solely provide a Value Proposition to facilitate value co-creation ***with*** the customer (Lusch & Vargo, 2006). Thus, the Value Proposition plays a key role in service innovation. Based on the reframed problem statement (see 7.2) and the Empathy Maps (see Appendix G), the Value Proposition Canvas was filled in (Strategyzer, 2020) (see Appendix J). From the Value Proposition Canvas, a Value Proposition for HWaaS was derived, as shown below:

Value Proposition

HWaaS allows healthcare organizations to measure and monitor the physical load that occurs during patient transfer unobtrusively, create awareness regarding physical overload and take targeted action to reduce it, as well as learn and share best practices.

8.2 IoT-Enabled Servitized BM

An important part of designing services is to consider the BM that enables the service, since changes to the service system require changes to the BM, and vice versa (Stickdorn et al., 2018). To make informed decisions regarding which BM to pursue, a literature review was conducted (as shown in Chapter 3), and a lunch lecture on the topic of servitization hosted by an innovation consultancy, was attended.

8.2.1 Challenges of Building the Business Case

Being able to calculate the Return on Investment (ROI) for the customer, helps the diffusion of healthcare technology in the healthcare market (Cain & Mittman, 2002). A common reason for failed market diffusion is a lacking Business Case, which insufficiently reduces costs or inefficiencies of the healthcare organisation (Oderanti et al., 2021). Thus, developing a Business Case, and sustainable BM around the HWaaS concept is important. However, since sickness absence and physical overload are complex issues, caused by several, interconnected factors, identifying the direct link between patient transfers using floor-driven patient lifts and sickness absence, requires dedicated, long-term research. Therefore, at the time of the project, making a simple ROI promise around HWaaS became a challenge. For esense to be able to make any claim regarding the efficacy of their solution, a longer study would be needed.

Cain and Mittman (2002) state that for innovation where specific outcome promises can not yet be made, positive customer experiences can enable successful diffusion in the healthcare market. As revealed through the stakeholder interviews, as well as desk research, healthcare organisations found the idea of receiving an evidence-based insight into the forces occurring on their work floor to be promising, despite it being difficult to know the exact impact of the intervention. Therefore, it was decided that esense should focus on how HWaaS can support the internal healthcare organisation in improving their physical overload prevention process, rather than making an explicit promise regarding ROI, and create positive customer experiences e.g. in pilot tests.

8.2.2 Choosing an IoT-Enabled Servitized BM

When manufacturing organizations take their first steps towards servitization, they must evaluate which capabilities are needed to provide the service system (Jovanovic et al., 2019). Therefore, Jovanovic et al. (2019) recommend a sequential approach to servitization, to avoid attempting to provide a complex service offering without the necessary capabilities in place. This sentiment was shared by an industry expert who hosted the lunch lecture on servitization that was attended. In this lecture, esense was given the recommendation to approach servitization in steps, not opting for the most complex alternative immediately.

As described in Chapter 3, Suppatvech et al. (2019) identify four BM archetypes for IoT-enabled servitization, being: (1) Add-on, (2) Sharing, (3) Usage and (4)

Solution-Oriented BM. In the Add-On and Solution-Oriented BM archetypes, IoT becomes integrated in the value proposition and takes on a more innovative role. The Sharing and Usage BM archetypes typically enhance the efficiency of asset use, and smoothen the flow of revenue, however, IoT is not very deeply integrated in the value proposition (Suppatvech et al., 2019). Since the goal of the project was to facilitate new value co-creation with the healthcare organizations in reducing physical overload, the Add-On and Solution-Oriented BMs were considered to be especially interesting.

To decide which BM to adopt for the HWaaS project, all four models mentioned by Suppatvech et al. (2019) were considered. The advantages and disadvantages of each BM archetype were discussed within the team, summarized in Table 8.

From the analysis, the Add-On BM was proposed for the HWaaS project, since it allows existing customers to purchase the service as an add-on (since healthcare organizations are often using the same patient lift for up to 10 years). This agrees with what was previously mentioned by Suppatvech et al. (2019), who encourages manufacturing organizations to adopt an Add-On BM as a first step, since it has a lower complexity, but with similar gains as the Solution-Oriented BM, including new revenue streams, a competitive advantage, and strengthened customer relationships.

8.2.3 The Add-On BM

To map the potential new Add-On BM, the Lean Canvas was used, as shown in Figure 14. The Lean Canvas is Ash Maurya's adaptation of the BM canvas initially presented by Osterwalder and Pigneur (2010), to better align with the lean start-up process (Maurya, 2012). Once the hypothesis has been ideated, tested and validated using the Lean Canvas, companies can make use of the BM Canvas, to make the plan more detailed (Skowron, 2020).

The lean canvas consists of 9 main building blocks: Problem, Solution, Key Metrics, Unique Value Proposition, Unfair Advantage, Channels, Customer Segments, Cost Structure & Revenue stream (Maurya, 2012). These were used to map out the different components of the HWaaS concept. However, the solution square was left to be filled in (something that is tackled in 8.3 - Ideation).

Table 8. Comparing the advantages and disadvantages of the IoT-Enabled Servitized BM Archetypes introduced by Suppatvech et al. (2019) for the HWaaS case.

BM Archetype	Advantages	Disadvantages
Add-On BM	• Integrates IoT in an innovative role • Easily available to existing customers • Lower complexity than solution-oriented BMs • Co-creates new value with customers, using data to improve their internal processes	• Relies on the customer owning or purchasing an esense patient lift, which is an expensive initial investment
Solution-Oriented BM	• Promising physical overload reduction, using the e-driven patient lifts, could be an innovative service offering in the market • The customer no longer pays for the individual products, but for the outcome of healthy working	• Complex solution • Longitudinal study is needed before making this promise • By selling this service as a solution, rather than an add-on to the existing products, this would be difficult to integrate with existing customers, who often are tied to their current patient lifts for up-to 10 years
Usage BM	• Healthcare organisations can pay for their usage (e.g. nr of transfers) in a subscription service	• Does not solve the problem statement, but simply makes asset use more efficient • IoT data collection is not deeply integrated in the value proposition
Sharing BM		• Does not solve the problem statement, but simply makes asset use more efficient • Organisations cannot easily share the patient lifts

PROBLEM	SOLUTION	UNIQUE VALUE PROPOSITION	UNFAIR ADVANTAGE	CUSTOMER SEGMENTS
Caregivers experience long-term physical complaints, from physical overload during patient transfer E-driven patient lifts takes time to get used to High work pressure limits time for caregivers Physical overload prevention is done 'ad-hoc' No insight into physica load	?	HWaaS helps healthcare organisations take a proactive approach to protect caregivers from physical overload during patient transfers, and work within recommended arbo-limits for push and pull forces. This is achieved by smart measurement and remote monitoring of the physical load that occurs in practice, and access to practices to promote safe and healthy transfer habits.	Co-creation with customers and experts in ergonomics	Institutional care facilities Caregivers carry out patient transfers using floor lifts Caregivers experience physical overload associated with patient transfer Organisation wants to invest in innovation to prevent & reduce physical overload International markets
EXISTING ALTERNATIVES	**KEY METRICS**	**HIGH-LEVEL CONCEPT**	**CHANNELS**	**EARLY ADOPTERS**
Ergometer Observations Survey Training	Number of registered locations Number of users Track-record on reducing physical overload	Remote monitoring of physical load during patient transfer	Dealers Direct marketing Trade shows Social media	Nursing homes in NL Interested in working with data Have esense lifts Have problem with physical overload and sickness absence

COST STRUCTURE	REVENUE STREAMS
R&D Salaries Simcard for IoT modules Material	Monthly subscription fee Additional fee for consultancy from experts

Figure 14. The Lean Canvas, adopted from (Maurya, 2012).

8.3 Ideation

Next, the researcher gathered a team of esense employees in two collaborative sessions to ideate potential solutions to the HWaaS project. The team consisted of one sales representative, the commercial director, the main researcher, as well as an innovation expert from Wordlenig.

8.3.1 Session 1: Brainwriting

In a planned ideation session at the esense office, Brainwriting was deployed. Brainwriting is an ideation method that helps a team generate many ideas in a short amount of time (Litcanu et al., 2015). During the brainwriting session, each team member is given a piece of paper, and five minutes to silently draw or write down three ideas to a certain prompt, after which they pass the paper to the next team-mate. Once all papers have been passed around to all participants, the session is over. Brainwriting offers several benefits over traditional brainstorming, such as helping teams overcome imbalanced social dynamics (since ideas are written down and shared quietly), work in a task-oriented manner, and is generally faster than traditional brainstorming (Litcanu et al., 2015). Since all individuals in the research team had many responsibilities and busy schedules outside of this meeting, making efficient use of the time was important.

The prompt that guided the ideation session was: ‘How can we design a service that (1) helps organisations control and monitor physical overload during patient transfer, (2) provides transparent and accessible IoT-collected data, (3) recommends evidence-based action, and (4) supports knowledge sharing’. The participants were encouraged to also write down ideas that were not exactly matching the prompt, as this was an explorative session. In 20 minutes the team managed to generate 45 ideas (see Figure 15).

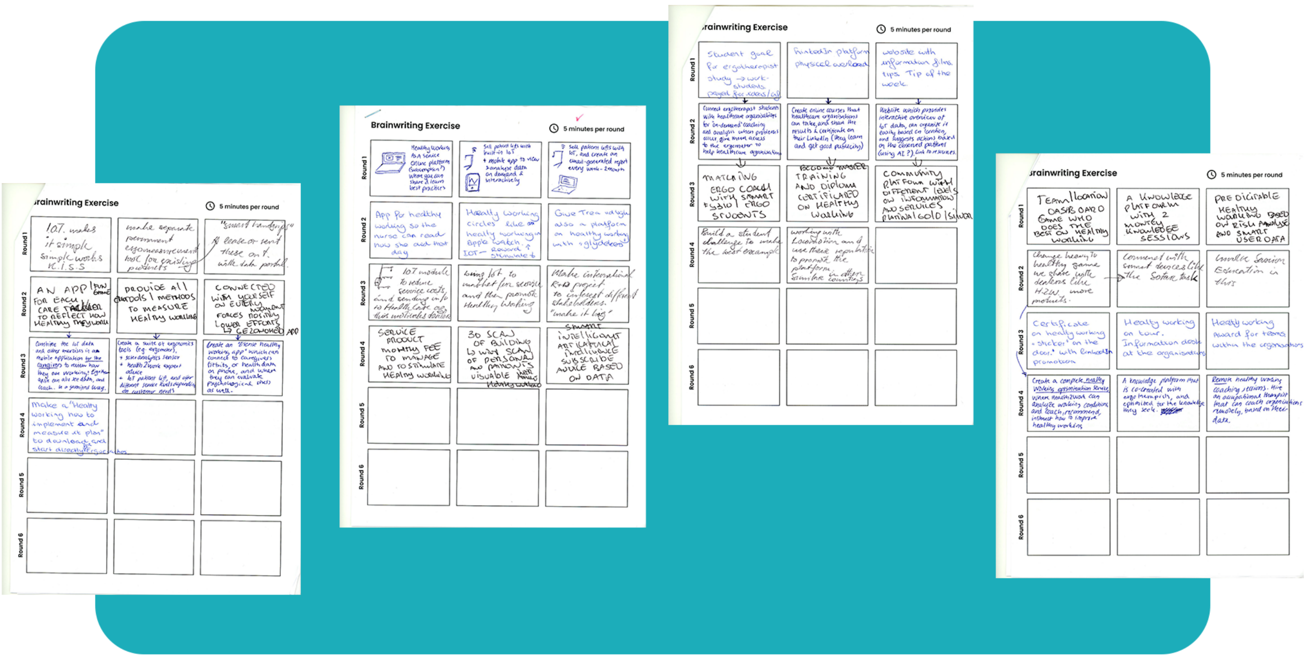

Figure 15. Scans of the ideas that were generated during the brainwriting session.

Promising Concept: Based on the discussions following the brainwriting exercise, the most promising concept ideas were identified, being:

A. Providing a service where IoT-data is summarized in a monthly email overview, and sent to key stakeholders within the healthcare organization.

B. Providing SaaS where an online dashboard allows users to log in and view the data collected by the patient lift.

C. Provide a service that informs the healthcare organizations about the best practices for healthy working.

D. Provide a consulting service, where esense, or an expert, intervenes if a high physical load is detected in the IoT-collected data.

E. Offer a service where healthcare organizations can ask for additional training based on their data.

8.3.2 Session 2: Idea Discussion

Before the second ideation session, the most promising concepts were mapped to the type of IoT-Enabled BM Archetype (Suppatvech et al., 2019) that they could be characterized as. This was done to identify what kind of BM could be built around the idea, as well as to inspire additional ideas, or combinations of ideas. Moreover, the concepts were evaluated on their suitability towards the target group and complexity level. These considerations are visualized in Table 9.

Table 9. Evaluation of the most promising concepts from the brainwriting session. Concept A-B is described in the previous section.

Concept	IoT-Enabled BM	Suitable for Target Group	Complexity
A.	Yes. Add-On	High.	Medium
B.	Yes. Add-On	Medium.	Medium
C.	No.	High.	Easy
D.	Yes. Solution-Oriented Consultancy	Medium	Complex
E.	Yes. Add-On	High.	Medium

This section describes the considerations for each of the identified concepts, which lead up to the final concept selection.

Evaluation of Concept A: Sending a monthly email with the collected ergonomic data - fits into the Add-On BM Archetype. Moreover, it would have high suitability for the target group, as it does not require any advanced technological skills, and would only require medium complexity for esense to develop. However, to not overload the user with information in this email (a potential threat identified in the user interviews), the data would have to be rather simplified, which may not provide sufficient information on its own to help the healthcare organisation identify when and where physical overload has occurred.

Evaluation of Concept B: Creating an online digital dashboard - would allow teams to access and track their data when they wish. This solution has the advantage of allowing the teams explore their data in more depth than what would be possible in an email. However, using platforms could be difficult for some caregivers. Therefore, user testing would be needed to explore the potential of this idea further.

Evaluation of Concept C: To provide customers with access to best practices - on its own does not utilize the IoT-collected data, and insufficiently solves the problem statement described in Chapter 7. However, it is a promising addition to the IoT data and has low complexity.

Evaluation of Concept D: Providing consultancy based on IoT insights - begins to become more complex, and blur the border between Add-on BM and Solution-Oriented BM. However, this solution would have high complexity to realise, it was decided that this idea would not be considered.

Evaluation of Concept E: Providing on-demand training - was considered a suitable addition to the IoT data, which would fit the needs of organisations where caregivers are struggling to adopt a certain behaviour.

8.4 Final Concept Selection

Based on the discussion regarding which potential PSS concept should be pursued (see 8.3), a combination of the four favorite concepts caught traction within the team (Figure 16). This meant combining the benefits and shortcomings of ideas A, B, C, and E in one integrated PSS concept. This combined PSS concept contains four main components: (1) an automated monthly email summary of the data sent to the ergo coaches and physio- or occupational therapists, (2) an online dashboard for continuous data monitoring, (3) an automated email alert that is sent to the ergo coaches at the time physical overload is recorded in a department, and (4) opportunities for the healthcare organisations to learn more about best practices and how to work with the patient lifts. Together, this information allows the team to monitor the physical load occurring in their department and learn how to take targeted action.

The proposed Service concept addresses the Value Proposition (see 8.1) in that it (1) allows healthcare organizations to measure and monitor the physical load that occurs during patient transfer unobtrusively using the monthly email summary and online dashboard, (2) creates awareness which can lead to targeted action through the the automated email alert, and (3) provides the customer with know-how and best practices regarding patient transfer.

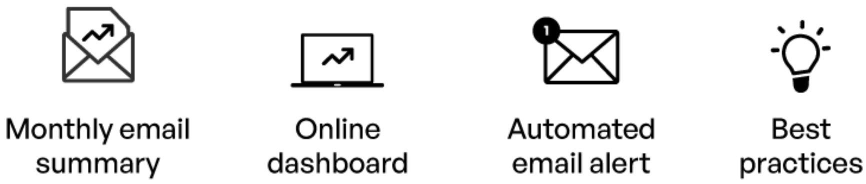

Figure 16. Visualisation of the four core components of the selected concept.

Moreover, the concept at this stage of the process was still rather open, and left plenty of space for the creation of a service design proposal to be tested with the target group. In the next chapters, this concept is developed in more detail, creating and testing a prototype (Chapter 9) as well as detailing the components of the proposed PSS (Chapter 10).

9. Validate

This chapter describes the fourth phase of the Triple Diamond Design Process: 'Validate'. Based on the findings from the user interviews, a prototype was to be designed and tested with the target market. Service prototypes are 'early forms' that stage a certain aspect of a service experience, e.g. interaction points, digital artifacts or ecosystems (Stickdorn et al., 2018). This chapter describes the prototyping process, and the following market experimentation.

9.1 Updated 'Riskiest' Assumptions

Based on the ideation phase, the list of 'riskiest assumptions' was updated. The 'riskiest' assumption was identified as the hypothesis that 'The data esense can gather from the IoT-connected patient lifts is valuable to the healthcare organisation' (See Table 10, assumption 6). This was seen as the most critical assumption, since the entire HWaaS concept was anchored in the idea of helping healthcare professionals acquire healthier habits, through the delivery of seamless data monitoring. Therefore, the next steps was to develop a prototype to create an early representation of the service experience. Since designers may choose to 'zoom in' on certain aspects of a service experience using prototypes (Stickdorn et al., 2018), it was decided that the most important aspect to test was the data-delivery of ergonomic data to the customer. Thus, the process of designing and testing this data delivery is explained in the following sections.

9.2 The Digital Prototype

9.2.1 Minimal Viable Solution

To evaluate whether customers found the data that esense could deliver valuable, it was decided that a Digital Prototype would be developed. Digital prototypes can be created at different levels of fidelity (Stickdorn et al., 2018). Since it was necessary to obtain quick feedback from the user group while still giving a representative idea of the service concept, a medium-level of fidelity was opted for. The goal was to develop a minimum viable solution to be tested with key stakeholders, which contained the monthly email summary, the online dashboard, and the automated email (see Figure 17). Moreover, the developed prototype could also be used as a prop to generate a discussion with users about what kind of additional features (e.g. best practices) they would like to see.

Table 10. Updated 'Riskiest Assumptions'
+ = Positive indication, - = Negative indication, ? = Not yet investigated.

	Updated Riskiest Assumptions	Evaluation
1	Physical overload caused by the incorrect use of patient lifts leads to physical complaints and sickness absence in caregivers, but it is currently impossible the exact extent.	+
2	Healthcare organizations are interested in receiving objective data collected by the patient lifts (using IoT) to measure and monitor the physical load that occurs on the work floor, but data is not everything, and privacy could be an issue.	+
3	Esense can build a desirable, feasible and viable IoT-enabled BM around the HWaaS project.	?
4	There is not enough evidence for the effectiveness of e-driven to reduce sickness absence at this point to make promises regarding ROI, however, healthcare organizations find the HWaaS value proposition attractive enough to be interested.	?
5	A PSS can be designed around the esense products and technologies that is desirable for the customers.	?
6	Customers find the data presented to be valuable to improve their internal physical overload prevention process.	?
7	It is sufficient for healthcare organizations to receive aggregated data on a team level, not on individual level, to protect caregiver privacy.	?

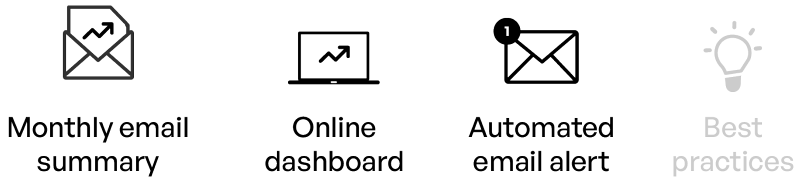

Figure 17. Visualisation summarizing the components of the prototype. The three core aspects of data visualisations would be prototyped, and then used as a prop to gather insights about what kind of support that end users would like to receive.

9.2.2 Prototype Development

The digital prototype was developed using Figma, a collaborative online interface design tool for building and animating digital prototypes (About Figma, n.d.). The design was done iteratively, getting feedback from a designer from Wordlenig, and esense employees. Once an acceptable version was reached, it was ready to be tested with users. In the following sections, the type of data that the patient lifts would collect and send using IoT, as well as, the three main service touchpoints of the digital prototype are explained, being: (1) the monthly email summary, (2) the online dashboard, and (3) the automated email alert.

Additionally, steps were taken to clarify which data could and would be collected by the IoT modules, which could be of value to the end customer. This data included the number of transfers made using the patient lift, the number of times forces above 15 or 20 kg were recorded, as well as time stamps associated with these events. Next, an important part of designing the prototype was to understand how this data could be presented in an interesting and valuable way to the end user.

9.2.3 Prototype Part A - The Monthly Email Summary

Healthcare professionals, such as ergo coaches, physio- and ergo therapists work under immense pressure. Therefore, it is important that esense delivers the data collected by the IoT patient lifts in a way that is accessible, and easy for the end-user to interact with. The healthcare professionals interviewed in the prototyping session explained that they often read emails as a part of their daily job. Therefore, receiving a monthly email summary of the data was opted for. The target persona for the monthly email summary were the ergo coaches, the physio therapists, and the occupational therapists, to give them an understanding of the physical load that occurs within their location or team. A visualization of the email can be seen in Figure 18. The email summary contained:

- Key Performance Indicators (number of patient transfers, the healthy transfer %, and the number of physical overload alerts)
- Benchmarking compared to other organizations
- Comparative analysis between multiple lifts
- Annual overview of healthy transfer %
- Empty take action box (to trigger discussion about additional features)

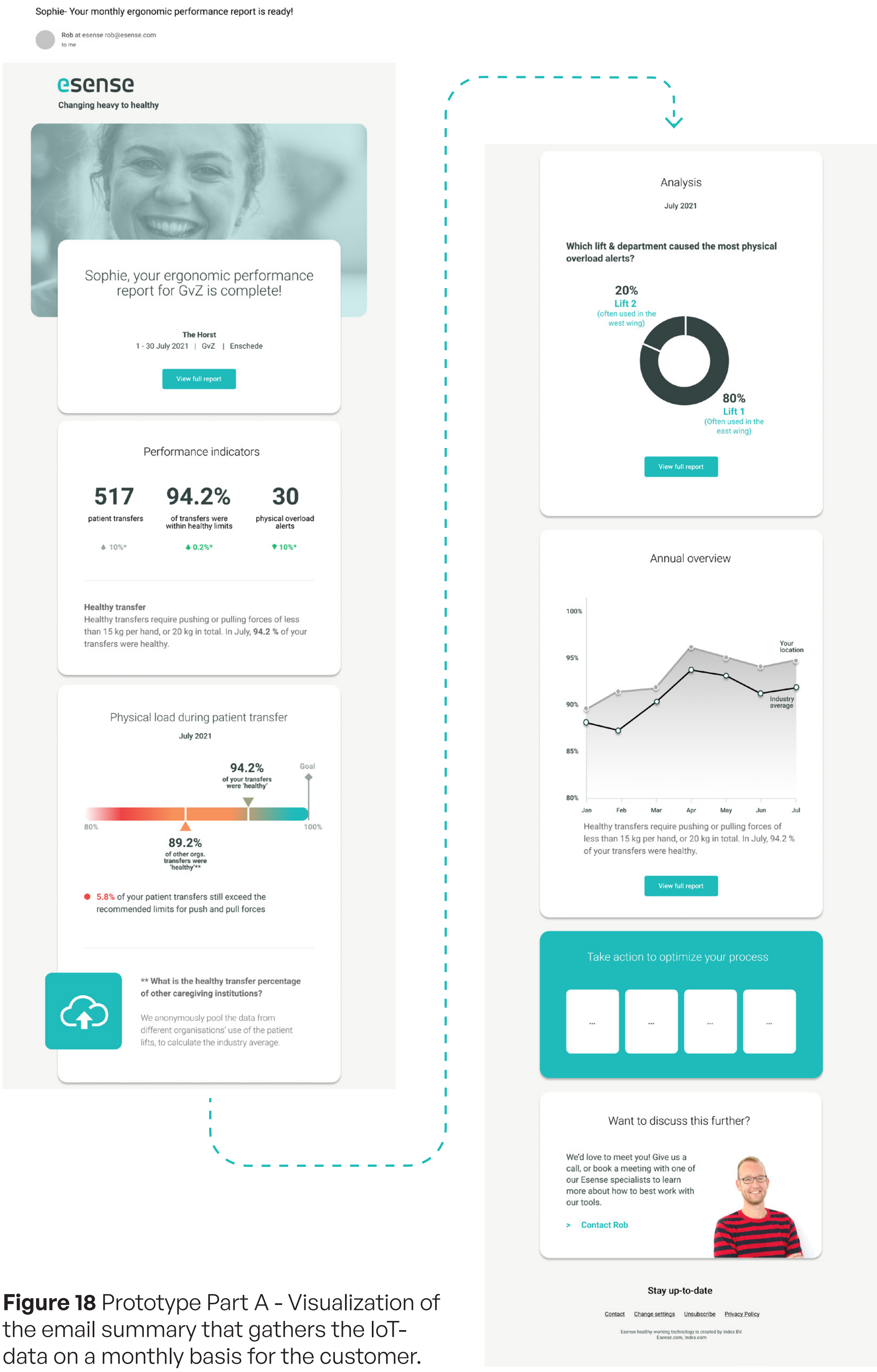

Figure 18 Prototype Part A - Visualization of the email summary that gathers the IoT-data on a monthly basis for the customer.

9.2.4 Prototype Part B - The Online Dashboard

In order to make the data available on-demand for the user, and give them the opportunity to dive deeper into the different physical overload events, an online dashboard was designed. A visualization of this dashboard is included in Figure 19. The dashboard contained:

- Benchmarking compared to other organizations
- Annual overview of healthy transfer %
- Information about teams and lifts
- Calendar with physical overload alerts
- Monthly overview with physical overload alerts

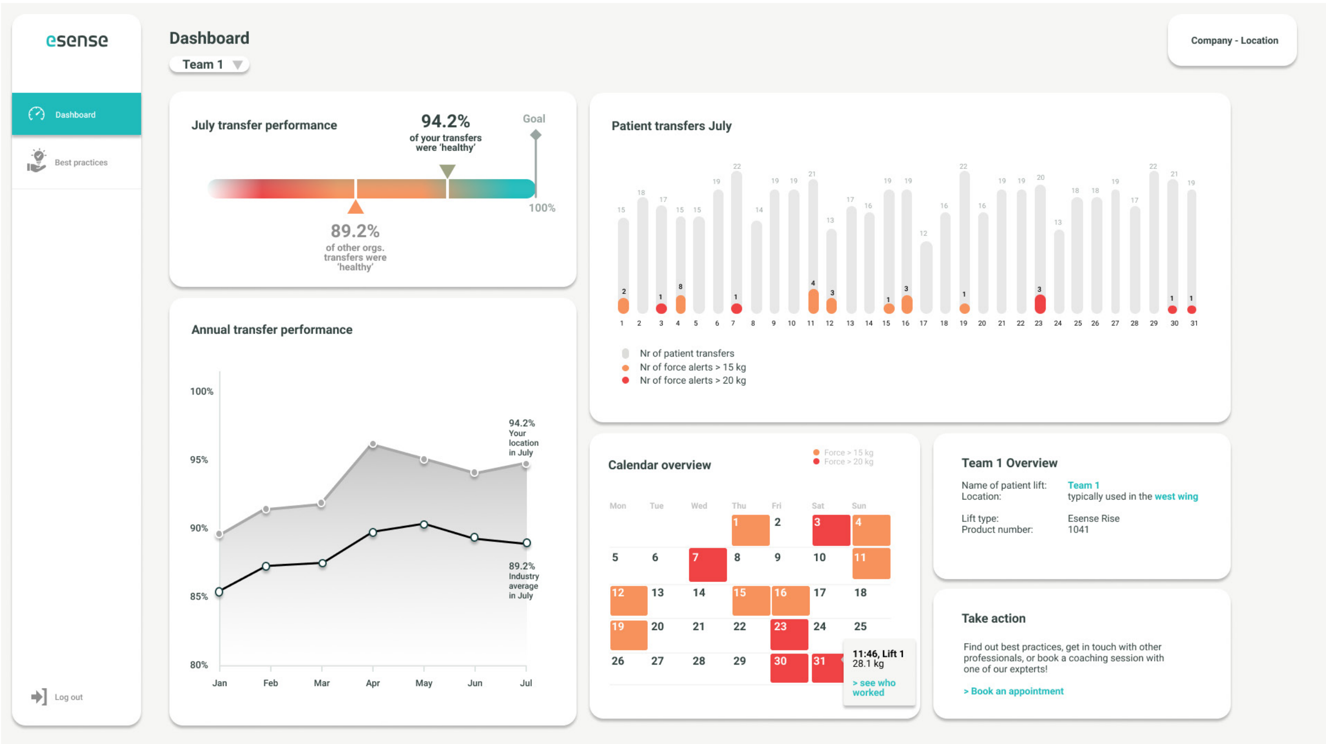

Figure 19. Part B of the prototype: the online dashboard.

9.2.5 Prototype Part C - The Email Alert

Additionally, an automated email was designed which would be sent to the ergo coach whenever a physical overload alert was recorded by a patient lift in their team (see Figure 20). This alert contained information about when and where the physical overload was recorded, from which patient lift, as well as the force magnitude, and movement. The intention of this email was to create immediate awareness for the professionals striving for the patient lifts to be used in a safe manner, to be able to discuss with their team when things go wrong.

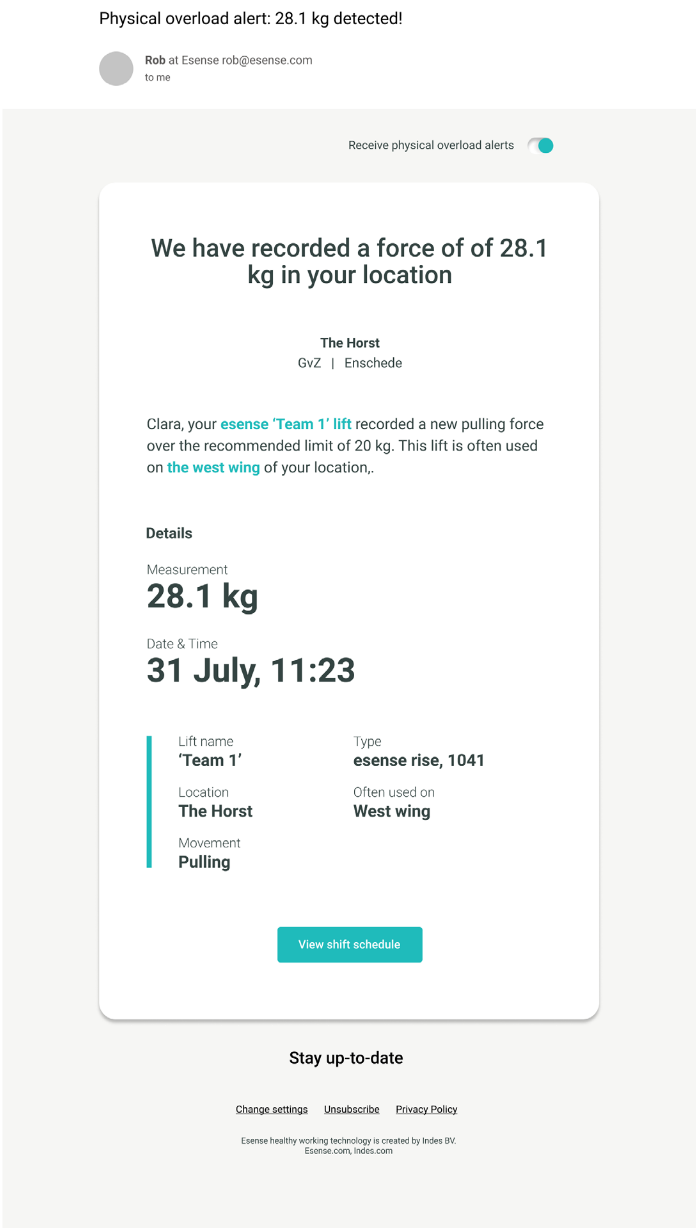

Figure 20. Part C of the prototype - The email alert.

9.3 Prototyping Session

9.3.1 Research Goal

The goal of this research activity was to validate the desirability of the HWaaS concept. Moreover, the 'Riskiest assumptions' regarding the customers interest in the solution were evaluated (see Table 11). Additionally, questions were asked to probe the participants regarding areas of improvement, and if healthcare organizations wanted additional supportive features to improve their internal physical overload prevention process.

Table 11. Updated 'Riskiest Assumptions' to be evaluated in the prototyping session. The numbers remain for the previously stated Riskiest assumptions, with some more assumptions added as well.

	Updated Riskiest Assumptions
6	Customers find the data presented to be valuable for improving their internal physical overload prevention process
7	It is sufficient for healthcare organizations to receive aggregated data on a team level, not on individual level, to protect caregiver privacy.
8	Customers find the way the data is presented (email and dashboard) to be appropriate for them to integrate in their way of working
9	Aside from the data, users wish to have supportive features to help caregivers use the patient lifts correctly.
10	Healthcare organizations with high interest in physical overload prevention and innovation are the target 'early adopters' for the HWaaS project, and show interest in integrating the HWaaS solution in their organization.
11	Ergo coaches want to receive an automated email when physical overload is detected in their team.

9.3.2 Protocol for Prototyping Session

To test the desirability of the service interface, an online user evaluation was held, also known as a Prototyping Session (Stickdorn et al., 2018). This session was done with 9 participants, consisting of 7 previous interviewees, 1 additional ergo coach who was recruited by one of the participants, as well as 1 expert in the field of ergonomics. An anonymized list of the participants can be found in Appendix

H. The prototyping session took one hour and was hosted online individually with the participants. The sessions were co-hosted together with an innovation expert from Wordlenig. The session consisted of three parts: (1) a co-creative exercise where a stakeholder network and flow chart was created of the internal actors and activities involved in preventing physical overload in their organisation, (2) the presentation of the prototype where the participant were asked to speak aloud their impressions and thoughts (Baxter et al., 2015), and (3) a semi-structured interview were evaluative questions were asked. The full protocol can be found in Appendix K.

9.3.3 Analysis

The sessions were recorded with the participants verbal consent, anonymized and transcribed (Baxter et al., 2015). Important quotes were noted down verbatim. Since the data contained insight gathered from users thinking aloud, as well as a semi-structured interview, it contained both structured data (i.e. the questions asked to validate the 'riskiest assumptions') and unstructured data (i.e. the user insights gathered from the think aloud method). Therefore, a customized approach was applied in this analysis, where key user feedback was noted down and tallied according to how many participants agreed with a sentiment (Baxter et al., 2015), in a summarized table (as shown in the Appendix L1). By ranking the list according to how many participants expressed similar sentiments, some themes emerged that were stronger than others. The emerging themes from this activity is presented in 9.4.

9.4 Results

Based on the analysis of the prototyping session, several key insights emerged, discussed in this chapter.

9.4.1 Evaluating Riskiest Assumptions

The prototyping session had, in part, aimed to validate the riskiest assumptions underlying the project (assumption 6 - 10, as shown in Table 12), with tallied responses in Appendix L2. Most of the assumptions that were tested in this session were evaluated positively, but to varying degrees. Assumption 6 (the value of the data), 7 (it is sufficient to collect data on a team level), 8 (the digital touch points are appropriate) and 9 (there is a need for additional features to support behavior change) were confirmed by a majority of the participants. Assumption

10 (innovative organizations are potential early adopters) had a positive indication from two of the participants from healthcare organizations that had a more structured approach to investing in innovation and sustainable employability. The only assumption that could not be validated, due to a conflicting response from the participants, was assumption 11 (ergo coaches want automatically generated emails when physical overload has been detected).

Table 12. Evaluation of the riskiest assumptions. The evidence strength is based on the number of participants that agreed with the same sentiment, as well as their conviction. +++ = at least 6 participants, ++ = more than 4 participants, + = at least 1 participant, +/- = conflicting opinions.

	Riskiest Assumptions	Evaluation
6	Customers find the data presented to be valuable for improving their internal physical overload prevention process	+++
7	It is sufficient for healthcare organizations to receive aggregated data on a team level, not on an individual level, to protect caregiver privacy.	+++
8	Customers find the way the data is presented (email and dashboard) to be appropriate for them to integrate in their way of working.	+++
9	Aside from the data, users wish to have supportive features to help caregivers use the patient lifts correctly.	+++
10	Healthcare organisations, with high interest in physical overload prevention and innovation, are the target 'early adopters' for the HWaaS project, and show interest in integrating the HWaaS solution in their organisation.	+
11	Ergo coaches want to receive an automated email when physical overload is detected in their team.	+/-

This section details the stakeholder feedback regarding the riskiest assumptions, and draws some key insights from these evaluations.

Assumption 6: Customers find the data presented to be valuable for improve their internal physical overload process. In the prototyping session, the service prototype was well received by 8 out of 9 participants, who found the data insightful and valuable. As P9 described it, "I think it is really nice and gives a clear overview! I am really enthusiastic about it. It is insightful, especially with the colors and the graphics.". Similarly, P5 stated: "It would help [the innovation coordinator] and the arbocoordinator to do a lot more work "data-based", instead of just based on gut feeling." Moreover, some participants believed that the solution could have direct impact on reducing the physical complaints in the departments. As mentioned by P8: "[with this solution] there would definitely be fewer shoulder complaints.", and P13: "Fewer people would have back problems". Moreover, 8 out of 9 participants thought it was good to be able to track the changes in healthy working percentage over the year. As mentioned by P2: "That could show a department that they are improving, which they are working on it. Or if they have some new patients that it changes. I think it gives a really practical overview".

However, even though most participants had an overall positive attitude towards the solution, some participants had hesitations to the extent which the solution would be effective, such as P10: "I still find it a little difficult to estimate how [the proposed solution] can be used in practice. [...]. I think that maybe by trying it out, and seeing what kind of data it collects, it is easier, than just saying that I want that now in every lift.". Thus, conducting pilot tests to evaluate the efficacy of the solution could be of high relevance.

» Key Insight: Risky assumption number 6 as validated by most participants, with some hesitating regarding the extent to which the solution would have an impact.

Assumption 7: It is sufficient for healthcare organisations to receive aggregated data on a team level, not on individual level, to protect caregiver privacy. 4 participants thought that it was sufficient to know this information on a team level, instead of individual, to protect caregiver privacy. No participants expressed a need to know exactly which caregiver had caused the physical overload alerts. However, even when data would be collected anonymously, and only displayed on a team-level, some participants had hesitations regarding privacy related issues.

» Key Insight: Risky assumption number 7 was validated by almost half of the participants, and not disputed by any of the participants.

Assumption 8: Customers find the way the data is presented (email and dashboard) to be appropriate for them to integrate in their way of working. In the research, 8 out of 9 participants found the way in which the service touchpoint was delivered (i.e. in the form of an email and access to an additional online dashboard), to be appropriate. As P8 described it, “[The email and dashboard] is nice [and helps you] assess the situation”. Users appreciated the look and feel, and that it was more focused on the positives than the negatives. P1 stated: “You are putting the focus on the healthy values, not the unhealthy once. I think that fits prevention-wise” However, P5 raised the concern that the issue with having an online dashboard, is that people may forget how to access it:“people have ‘gazzilion’ accounts for everything [...] and you always have to log in with an email and password [...] If people forget their passwords, they would stop using it.” Thus, considering how the platform is accessed, in a safe and easy way, deserves further investigation.

» Key Insight: Risky assumption number 8 was validated by almost all of the participants.

Assumption 9: Aside from the data, users wish to have supportive features to help caregivers use the patient lifts correctly. Although participants found the data valuable in creating insights, and helping organisations make evidence-based decisions regarding interventions and investments, the data alone is potentially not enough to produce healthy behaviour change in caregivers. Several participants suggested that additional supporting features could help organisations better inform their caregivers how to use the tools better. As P5 described it: “I think that for me, on a high level, the data would be enough. [...] But I think that on a work floor level, if you need to use the lifts every day, and teach and train your colleagues how to use them, the help of an expert, or videos, or other prompts, would be welcomed”. The kind of supporting features that users were interested in seeing included: (1) Best practices, tips & tricks, and knowledge sharing, (2) Instructional videos, and (3) Expert appointments. In total, 8 out of 9 participants expressed interest in viewing instructional videos to learn how to better use the patient lifts, especially in certain scenarios like small rooms or with heavy patients. Moreover, to make the information easily digestible for busy caregivers, the advice was given to use of a lot of visual elements. 7 out of 9 participants were interested in getting external input on how to improve their working ways, for certain, complex scenarios. This support could most optimally be given on the work floor, but in some cases, it could also work in an online space.

» Key insight: Risky assumption number 9 as validated by almost all of the participants. Healthcare organisations are potentially interested in instructional videos, tips & tricks regarding best practices, and the ability to book appointments with ergonomic experts.

Assumption 10: Healthcare organisations with high interest in physical overload prevention and innovation are the target 'early adopters' for the HWaaS project, and show interest in integrating the HWaaS solution in their organisation. Two healthcare professionals from different organisations - both with a clearer strategy regarding physical overload prevention than average - expressed interest in implementing the service offering. P9 mentioned: "I don't really see a big challenge in implementing this solution in our organization. Because, at this moment, our organization is really focusing on healthy working, which I have noticed is important for our employees that are 60 years or above. I am sure higher management would be excited about it too!". Additionally one participant expressed direct interest in partaking in a pilot test. However, some healthcare organisations with a less coordinated approach to physical overload prevention had their doubts regarding the possibility to implement the solution on a larger scale. P8 stated: "I think to get it on the work floor [would be the biggest challenge], because management would have to choose this solution. It takes sometimes, and budget plays a big part.". This supported the assumption that healthcare organisations with a focus on physical overload prevention would be the target early adopters for this solution.

- Key Insight: Risky assumption number 10 was validated by two 'innovator' healthcare organisations.

Assumption 11: Ergo coaches want to receive an automated email when physical overload is detected in their team. Two participants expressed great interest in the automated 'ergo alert' emails (automatically generated and sent emails when push and pull forces exceed recommended limits), while other participants found the feature to be overwhelming. P8 liked the feature, saying: "This is really nice! With this information we can easily take action. It is also nice that it shows the time, then you can search specifically who caused it.". On the other hand, P2 stated: "Personally, I think this is very interesting data, but I think it would drive me crazy if I got an email every time this happens.". Thus, this suggest that the automatic email alert functionality must be further investigated before it can be confirmed whether it is a valuable enough addition to the service, and if implemented, the functionality should be optional.

- Key Insight: Risky assumption number 11 could not be fully validated, since stakeholders had highly varying opinions on the matter. Thus, the feature may not be crucial to the solution, and if implemented, it should be optional.

Thus, based on the feedback in the prototyping session, customers found the proposed solution valuable. However, the privacy of caregivers remained a topic of concern, and the automated email feature could not be fully validated.

9.4.2 Additional Insights & Feedback

Separate from validating the key assumptions, additional feedback was also gathered from the participants, noted in Table 13. These feedback points are discussed in this section.

Table 13. Additional user feedback gathered in the prototyping session.
+++ = at least 6 participants, ++ = more than 4 participants, + = at least 1 participant, +/- =conflicting opinions.

	Feedback	Evaluation
A	Users want more details to be able to see when and where an ergo alert happens, and what kind of movement & magnitude.	+++
B	There are several stakeholders in the organisation that are interested in the data:	+++
	• Ergo coach	+++
	• Location manager	+++
	• Arbo-Coordinator	+++
	• Occupational- and physiotherapists	++
	• Human resources & policy officers	+
C	Industry benchmarking is unnecessary, and not really that interesting	++
D	Management users would like more advanced ways to analyse the data.	++

Insight A: Users want more details to be able to see when and where an ergo alert happens, and what kind of movement & magnitude. All participants wanted to be able to retrieve clear information regarding when physical overload was recorded, inluding the time, the day, and from which lift or team the alert was generated. However, most participants thought that it was sufficient to know this information on a team level, instead of individual, to protect caregiver privacy. Moreover, the participants suggested that the caregivers themselves would be give access to this solution, making the data monitoring a group effort.

When observing the user interpret the prototype, it became clear that most users found the detailed information regarding when the physical overload occurred in the ergo alert email. The daily overview feature in the dashboard helped, but did not contain detailed information about what time a physical overload was recorded.

» Points of Improvement: Add clear information to the online platform about when and where physical overload occurs.

» Points of Improvement: Place focus on the data collecting being a team effort, and give caregivers access to the platform.

Insight B: There are several stakeholders in the organisations interested in the data. All the participants could think of stakeholders within their organisation that could be interested in the information presented in the service prototype (see tallied responses of roles in Appendix L3). The most mentioned user was the ergo coach, mentioned by 9 out of 9 participants. The ergo coach can act based on the data on a weekly basis, to make improvements to the way caregivers work directly. The second most mentioned stakeholder types were the Location Manager, and the Arbo coordinator (mentioned by 6 out of 9 participants). The location manager can look at the data to make more well-informed decisions regarding e.g. the procurement and training for aids. The Arbo-Coordinator can use the information to improve training and policy. As mentioned by P5: "I can imagine that if we have [lift-specific] training every 6 months, which [the arbo coordinator] would check beforehand what the data is in a certain location, to find out about whether or not things are going well, to adjust the training [...], and then check in half a year to see: has it really improved?" Other relevant stakeholders that could be of interest are the Physio- and occupational therapists, Human Resources, as well as the general policy staff. Moreover, the type of user may be interested of information on different levels of data overview.

» Points of Improvement: Give different users access to different levels of information.

Insight C: Industry benchmarking is unnecessary, and not really that interesting. Most of the participants expressed that seeing the comparison to other organisations was not that interesting. As mentioned by P2: "[I am only interested in] looking at my own locations". Similarly, P5 stated: "I am not sure I would want to know the healthy transfers of other organisations, because if we are doing better than them, which may send out the signal that we are doing just fine, which we don't have to change anything, and I don't really like that. Every little bit that you can change is good, especially in this really physically heavy work, because it really saves us a lot of work-related illnesses.". This indicates that benchmarking the healthy transfer percentage against other organisations is an unwanted feature for healthcare organisations.

» Points of Improvement: Remove industry benchmarking feature.

Insight D: Management users would like more advanced ways to analyse the data. 4 participants expressed interest in being able to sort the data so that they could compare the physical load that occurs to different types of patient groups. P10 explained: "You can imagine that patient groups with somatic complaints, vs. groups with dementia need different care. The care profile matters". It would also be nice if the data could somehow be compared to e.g. sickness absence, by allowing the user to download an excel sheet. "I can imagine that the percentage of healthy transfers is impacted by the number of replacement staff members we have at that time. For example, during the holidays, or when a lot of regulars are ill [...] So I would be interested to see if that actually matches. " (P5).

» Points of Improvement: Connect IoT data to patient mobility class

9.5 Key Takeaways

Based on the outcomes of the user research phase, several possible solutions were imagined. After comparing the potential solutions, one winning concept was chosen to be developed into a prototype. This prototype consisted of a summarized monthly email, an online dashboard, and an automated email report that is generated when the patient lifts detect high pushing or pulling forces. This prototype was tested with members of the target group. The outcomes of the qualitative research were analysed, and key insights emerged. Most importantly, the test validated three main components of the service: The usefulness of the monthly email, and the online dashboard, as well as an interest in accessing best practices in the form of videos, tips & tricks, or an expert meeting. The fourth feature, being that users want to receive automated emails, had mixed results, and was not seen as a core feature of the service. Therefore, the most promising service features are summarized in Figure 21.

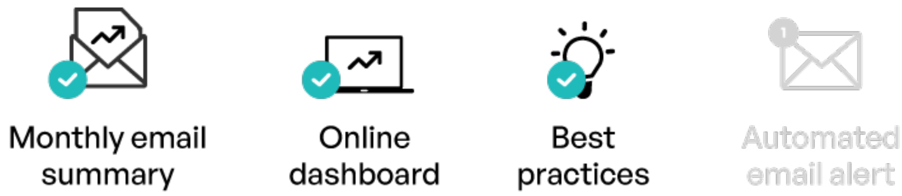

Figure 21. Validated key features of the service prototype.

10. Final Concept & Pilot Recommendations

In order to bridge the gap between service design concept and implementation (Mulgan, 2014), the fifth phase of the Triple Diamond Design Process focused on preparing the service concept for implementation. As illustrated in the validation phase, the proposed HWaaS concept can fill a need in the target market, namely: helping healthcare organizations adopt a preventive and evidence-based strategy to tackle physical overload, rather than a reactive one. Based on the insight gathered in prototyping sessions, a final designed PSS proposal was developed. The modeling of the future service system consisted of three main components: a refined UI design of the digital service touch points (10.1), a future service blueprint (10.2), and a future BM (10.3) (see Figure 23 - 26, and Appendix M). Moreover, to make the designed concept more actionable for the pilot phase, a simplified UI and Service Blueprint was designed (10.4). In the following sections, these deliverables are detailed.

10.1 Digital Service Touchpoints

The prototyping session had given a positive indication that healthcare organizations found the IoT-collected data to be valuable. Moreover, the research indicated that healthcare organizations could gain more value-in-context from the service offering through access to best practices. This could be done in the form of tips and tricks, instructional videos, or meetings with ergonomic experts. Additionally, the idea to give the customer an automated email alert when physical overload was detected was not fully validated in the user interviews. Therefore, this feature was excluded from the future service offering. Based on these insights, improvements were made to the digital service touch points. These changes are shown in Figure 22-26.

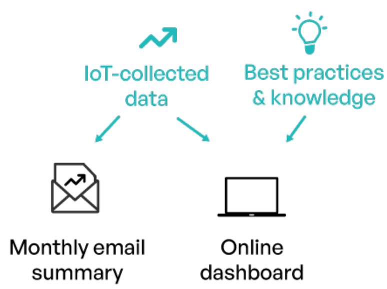

Figure 22. The key components of the software side of the IoT-enabled PSS.

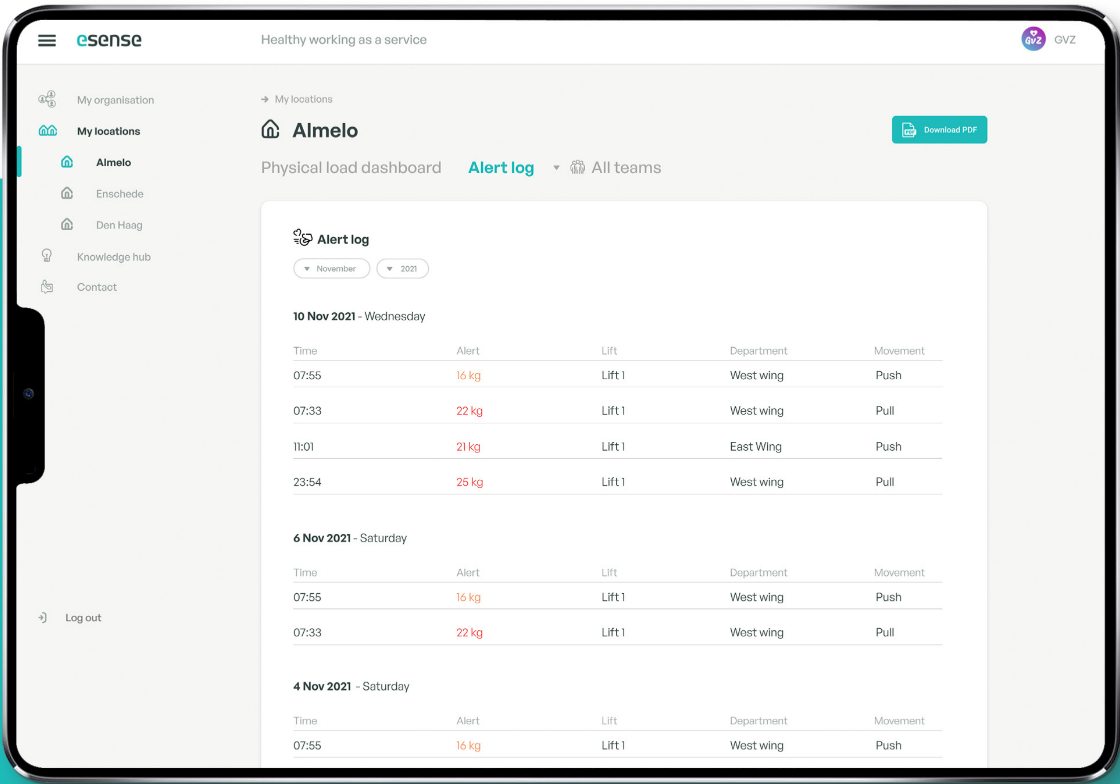

Figure 23. (Top) New 'Alert Log' page under the 'My Locations' tab.

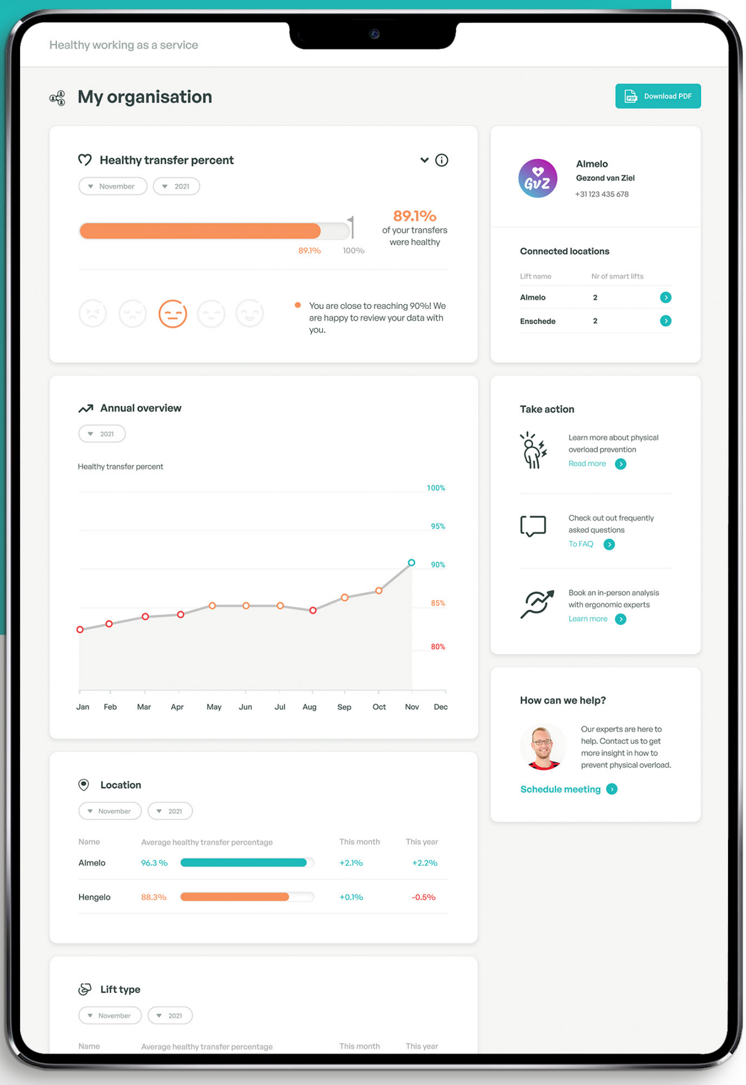

Figure 24. (Right) New 'My Organisation' page for higher management and Arbo-Coordinators to overview aggregate data from all connected locations.

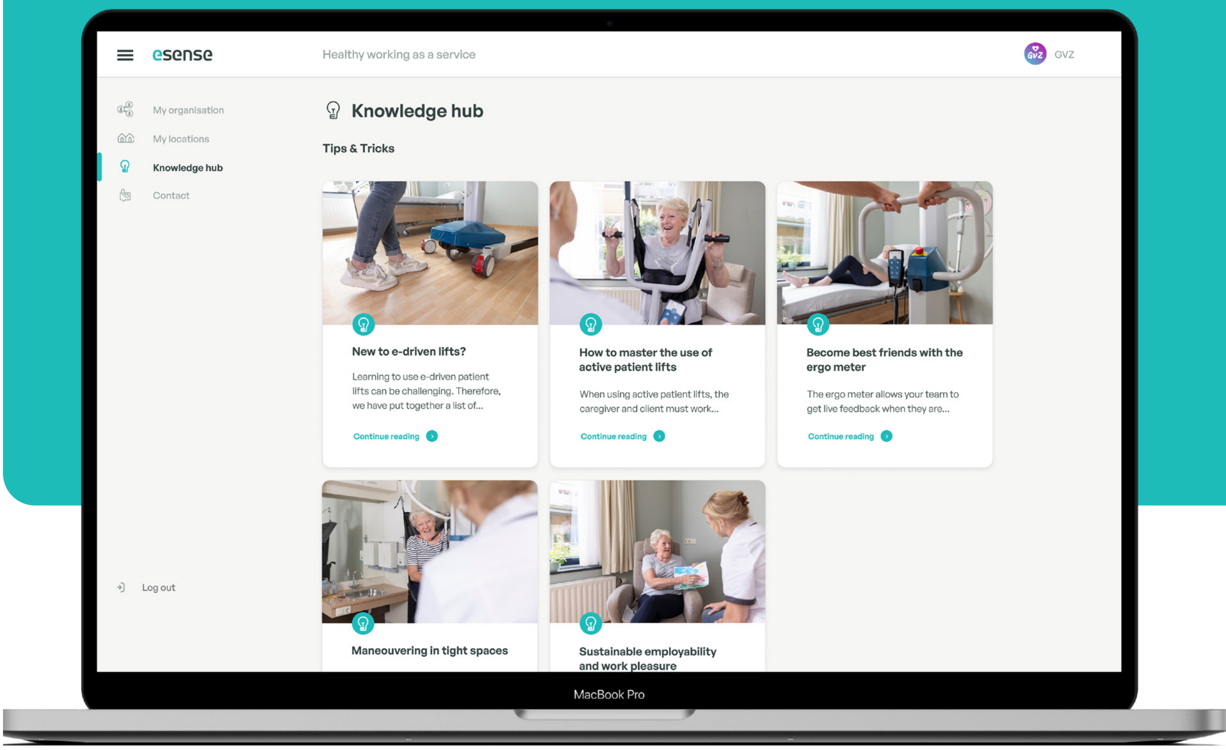

Figure 25. (Top) New email summary. **Figure 26. (Bottom)** New 'Knowledge Hub' page.

Based on the request for more advanced data analyis features, as well a access to best practices, the online dashboard concept evolved into an online platform for HWaaS, as explained in 10.1.1.

10.1.1 Future Online Platform

In the prototyping session, it became clear that different user types have different needs from the data collection. On the team level, ergo coaches are interested in seeing when and where physical overload has occurred, so that they can speak to the people who may have been involved. They are also interested in finding out more about best practices, and having access ‘how to’ videos regarding patient lift handling, as well as potentially having access ergonomic experts when they are encountering especially difficult physical overload scenarios. A location manager or physiotherapist may check in on the physical load less frequently, but enough to stay informed about the situation in their locations. Arbo-Coordinators and higher management may be interested in looking at the data from an organizational perspective, pooling data from different locations. Because of these differing user needs, the future digital platform concept contains four different pages (see sitemap in Figure 27): My Organization, My Location, Knowledge hub and Contact page.

My Organization (see Appendix M1) contains information intended for higher management, such as the arbo coordinator, human resources management, policy makers and board members. Here, the user can view the ‘healthy transfer percentage’ for the whole organisations, as well as per location, lift type, or patient mobility class.

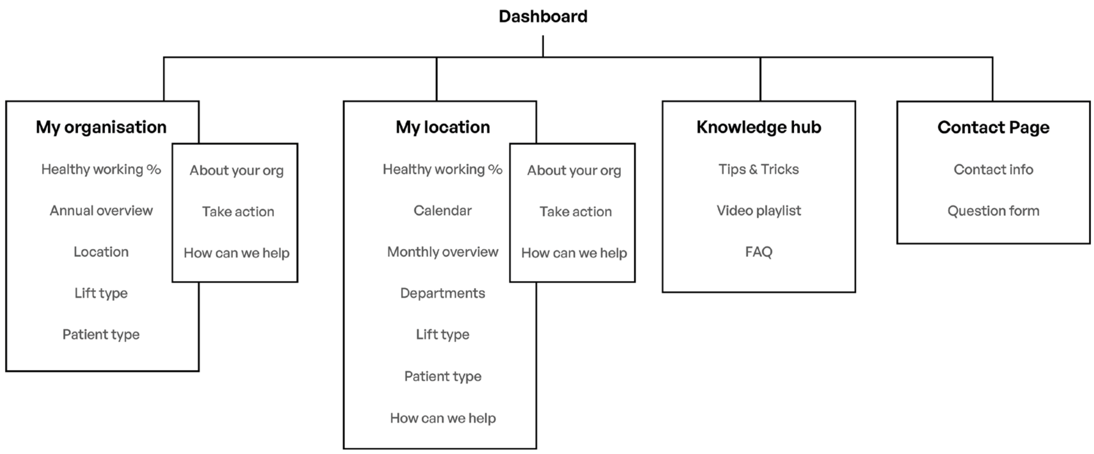

Figure 27. The sitemap of the proposed future HWaaS online platform.

My Location (see Appendix M2 & M3) contains information regarding the 'healthy transfer %' of the location, but can also be filtered according to the different teams or departments in the location. Additionally the user can view information about when physical overload has occurred, either in the Dashboard (Appendix M2) or by viewing the Alert Log (Appendix M3).

The Knowledge Hub (see Appendix M4) contains esense curated content such as interesting short blog posts regarding physical overload prevention, a playlist of instructional videos, as well as frequently asked questions. This is in response to the desire from users to help caregivers learn how to use the available tools, in a visual and fun way. By gathering best practices regarding patient lifts, and especially the esense product range, healthcare organisations have a place to turn to when investigating how to improve heavy transfer situations.

The Contact Page (see Appendix M5) contains information for the user to reach esense staff, either via email or a phone call, to discuss the data, and potentially book consulting sessions with ergonomic experts.

10.1.2 Future Email Summary Report

The email summary had generally been well-received by the stakeholders, and therefore only received minor updates to make the ergo alerts easier to view. The changes made to the email included removing the industry benchmarking, and adding an easier calendar overview to better show when and where physical overload was detected. Moreover, the user could now opt whether they want to receive the email weekly or monthly, since ergo coaches wanted to receive the data more often, to make sure that sufficient action can be taken in time. The full visualization of the email can be found in Appendix M6, which was also adapted to be used in a potential Pilot-test scenario.

10.2 Future Service Blueprint

To imagine how the service could be delivered, a co-creative online workshop was held with four esense employees, to create a future service blueprint. A service blueprint helps visualise the front stage (customer actions and service touchpoints) with the back stage processes that enable the service system (Stickdorn et al., 2018). The workshop was carried out together with four esense employees, representing perspectives from software engineering, innovation and strategy, sales and management. Together, the employees and the researchers imagined customer actions, service touchpoints, front and back office actions as well as support practices. The service blueprint was co-created using the online tool Miro (n.d.), and is visualised in Appendix M7.

This service blueprint illustrates a future where the collection of IoT data is automatically visualized and made available to the end users via email reports and the online platform. The main activities that are needed from the front office is supporting the customer in onboarding, as well as throughout the use phase, to support the customer in case they need additional support. In the back office, the core activity is to curate content relevant for the healthcare organizations, develop new software, and manage the collected data in a safe and efficient way. The supportive processes mainly focus on ensuring that the Iot modules or patient lifts are delivered, installed, activated and fully functioning.

10.3 Future BM

Using the BM Canvas (Osterwalder & Pigneur, 2010), a future IoT-enabled Add-On BM was modelled. The BM canvas helps establish a shared language for exploring new strategic BMs, which easily breaks down the rationale of delivering and capturing value into nine building blocks. This activity helped describe a future vision for esense, where HWaaS is sold as an Add-On subscription, alongside the sale of the patient lifts, creating a new revenue stream, and an IoT-enabled PSS. The goal of this PSS is to facilitate new value co-creation with customers, by helping caregivers work within recommended Arbo-limits for pushing and pulling forces, provide an evidence-based insight into the physical load that occurs on the work floor, embrace a proactive rather than reactive approach to physical overload prevention, as well as learn best practices regarding patient lift handling. The key activities from esense side would involve being available to answer questions from customers, arranging training with experts on the customers site, curating the 'best practices' part of the platform, and releasing continuous software updates. Through these activities, the relationship between esense and the end customer can strengthen. The full scope of the new BM is described in Figure 28.

10.4 Pilot Recommendations

HWaaS can benefit from being carried out in a long-term study, to improve and co-create the service together with a healthcare organisation, validate the technical functionalities and potentially investigate the impact of the project on improving healthcare organisations approach to physical overload prevention.

<table>
<tr>
<td rowspan="2">KEY PARTNERS
Dealers
Arbo services
Software developers</td>
<td>KEY ACTIVITIES
Replying to customer questions
Procure best practices page on dashboard
Training
Software development & updates</td>
<td rowspan="2" colspan="2">VALUE PROPOSITION
Help your team work within recommended arbo-limits
Give your team insight into real physical overload on the workfloor
Take proactive approach to improve high-risk situations, based on data
Monitor, control and prevent physical overload during patient transfer
Learn best practices for safe & healthy patient transfer</td>
<td>CUSTOMER RELATIONSHIPS
Service provision
Training</td>
<td rowspan="2">CUSTOMER SEGMENTS
Institutional care facilities in need of floor-driven patient lifts
Organisations who recignize the role of innovation in reducing sickness absence
Have problem with phsyical overload
International market
Have, or are buying, an esense patient lift</td>
</tr>
<tr>
<td>KEY RESOURCES
Integrated software and hardware solution
Relationships with customers and partners
User experience
Knowledge</td>
<td>CHANNELS
Dealers
Direct marketing
Online marketing
Advertisement
Word of mouth</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
R&D
Salaries
Marketing
Logistics
Production</td>
<td colspan="3">REVENUE STREAMS
Sale of patient lifts
Monthly subscriptions to HWaaS (Add-On)
Extra sessions with experts when needed (for fee)</td>
</tr>
</table>

Figure 28. The future BM Canvas, adopted from Osterwalder and Pigneur (2010).

Therefore, carrying out a pilot with a healthcare organisation was identified as the next step for esense. The field of service design is often criticized for insufficiently considering the implementation stage of new service systems (Mulgan, 2014). Through the application of the Triple Diamond Design Process, which was customized to fit the healthcare context, this project bridged this gap, by going past only proposing a service concept, to also being involved in the planning of the pilot testing phase, and initial conversations with the software developers. However, conducting the pilot laid outside the scope of this project. Four deliverables were made as a part of the future recommendations phase: (1) A service blueprint for the pilot test, (2) A simplified UI, (3) a onboarding survey that would be used in the initial meetings with the participating pilot organizations, as well as (4) general recommendations for the pilot test. These deliverables are described in this section.

10.4.1 Pilot Service Blueprint

Similarly to the future service blueprint, a Pilot Service Blueprint (Stickdorn et al., 2018) was created, based on conversations and insights from esense employees. This blueprint can be used as a guide for when carrying out the pilot with

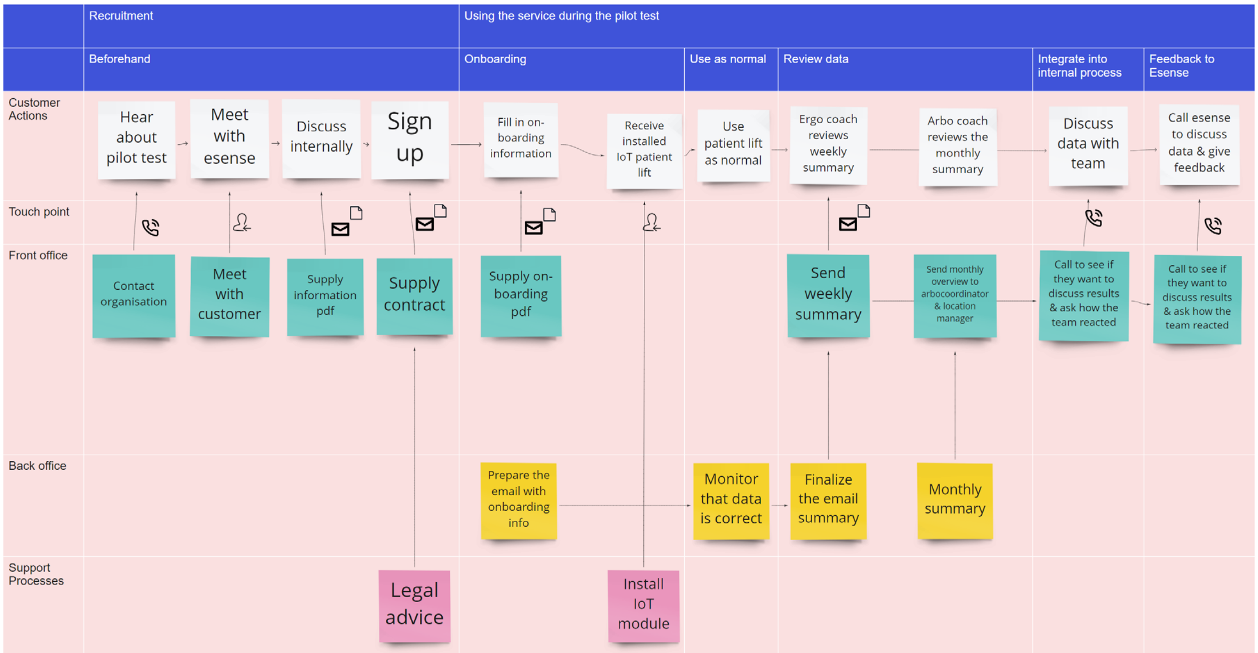

Figure 29. Service Blueprint for the pilot phase.

healthcare organizations (see Figure 29). The pilot test requires more manual work from the front and back-end office, where e.g. recruitment and onboarding needs to be done by taking active initiative to collaborate with healthcare organizations, and this contact needs to continue throughout the pilot test period, to collect user insight. The data delivery can however be automated, using a simplified version of the user interface for the online platform, and automated email, as explained in the following sections.

10.4.2 Simplified Pilot UI

To continue the R&D activities for HWaaS, a simplified UI was designed, focusing on the core functionalities, being 'My Location' and the 'Alert Log' alert log (see Appendix N), removing the 'Knowledge Hub' and 'Contact Page'. This was done so that the pilot test could focus on optimizing the data delivery, while simultaneously collaborating with the healthcare organisations to investigate, and co-create, potential service offerings that would fit their needs, including tips and tricks, instructional videos and frequently asked questions. However, the links in the "Take action" box, were kept, to allow users to click the link that they find the most interesting. When they click the link, a pop-up appears that explains to the user that this feature is coming later this year. By doing this, esense can test which additional services gain the most clicks, and therefore make sure to include those in the 'Knowledge Hub' page. The UI was designed and presented to the developers in a short report, as well as in an online meeting.

10.4.3 Onboarding Questionnaire

For the pilot test, an onboarding questionnaire was designed (see Figure 30 and Appendix O). This survey can be used to help esense employees gather information about the internal processes of the healthcare organization at the beginning of the pilot test, the expectations of the participants, as well as the relevant contact people. Additionally, the onboarding questionnaire gathers the data necessary to link a certain team or department to a particular patient lift. This data can then be linked by an admin in the HWaaS platform, to be able to visualize the data in a clear way, both on the website, and in the email reports.

Figure 30. Visualization of onboarding questionnaire.

10.4.4 Recommendations for Pilot Phase

To guide the pilot, one, or multiple research goals should be formulated. In Table 14, seven potential research goals have been suggested. Goal 1-4 investigate the service experience. Testing that the technical solution works is key, or else the entire value proposition (working evidence-based) is threatened. Goal 5-7 could provide evidence for the efficacy of the service in reducing physical overload, but requires higher scientific rigour and more extensive planning. The researcher recommends that esense at least covers goal 1-3, with potentially adding more research goals depending on the capacity of the research team carrying out the pilot test.

Table 14. Important research goals for the pilot phase.

	Feedback
1	Test the technical accuracy and reliability of the data collection and delivery
2	Evaluate and improve the UX/UI with the service touch points (e.g. online platform, email, and support from esense staff)
3	Investigate healthcare organizations willingness to pay for this service
4	Investigate user ideas and needs for additional services, such as content for the knowledge hub, or contact with external experts
5	Study the impact of the esense 'Healthy working as a service' on healthcare organizations approach to physical overload prevention (measure the internal processes pre- and post-pilot test)
6	Study the impact of esense 'Healthy working as a service' on sickness absence (measure pre- and post pilot-test) in a scientifically sound way, taking support from external experts
7	Study the impact of esense 'Healthy working as a service' on the average physical overload, per week (does it change over time)?

Part E.

Discussion & Conclusion

11. Discussion

This chapter discusses the research conducted in this project, guided by the research questions posed in Chapter 1.

11.1 The Role of Service Design for Servitization

The service economy has seen rapid growth in the last decades (World Bank, 2019). Alongside this development, 'Service' is increasingly recognized as a process of applying resources (e.g. knowledge and skills) to facilitate value co-creation with stakeholders, where the value is assessed based on value-in-context (Grönroos, 2006; Holmlid et al., 2017; Lusch & Vargo, 2006; Vargo & Lusch, 2004; Wetter-Edman et al., 2014). In this new service-oriented marketplace, firms must re-evaluate how they can capture and co-create value with their customers (Teece, 2010). Therefore, manufacturers are increasingly exploring servitization – the strategic switch from selling products to selling Product-Service Systems (PSS) – to generate new value for customers and increase competitiveness (Baines et al., 2009).

Service design is a human-centered, holistic, and interdisciplinary approach to service innovation, which deploys design thinking and an array of designerly tools and methods, to facilitate value co-creation with key stakeholders, such as customers and end users (Meroni & Sangiorgi, 2011; Sangiorgi & Prendiville, 2017; Stickdorn et al., 2018; Stickdorn et al., 2011). Research suggests that deploying service design can help manufacturers in developing PSS, anchored in a human-centered perspective (Costa et al., 2017).

In the case conducted in this thesis for the healthcare technology manufacturer esense, service design was implemented, and proved valuable in identify and addressing stakeholder pain points and translating these insights into a validated service concept. Through continuous stakeholder involvement in the form of semi-structured interviews, using service design tools such as Stakeholder Mapping, Journey Mapping, Personas, Service Prototyping and Service Blueprints (e.g. Stickdorn et al., 2018), helped the researcher in identifying and synthesizing the needs and context of the target group. Furthermore, by continuously engaging with key stakeholders, the servitization journey became customer-centric rather than product-centric. Thus, this research project agrees with previous literature (e.g. Costa et al., 2017) that service design can be beneficial for manufacturers pursuing servitization.

11.2 The Role of IoT in Servitization for Manufacturers Targeting Healthcare 4.0

Servitization and Industry 4.0 are two influential trends for the development of manufacturing (Frank et al., 2019b), as well as healthcare (Aceto et al., 2020). These trends are facilitated by smart technologies like IoT, big data, and cloud computing (Suppatvech et al., 2019). IoT can be understood as a network of internet- and sensor-connected entities that can be identified, located and acted upon remotely (Ng & Wakenshaw, 2016). IoT can benefit healthcare in several ways, e.g. closing the design loop between the manufacturer and the user, predictive maintenance and offering SaaS solutions (Aceto et al., 2020).

In the HWaaS case conducted for esense, the integration of IoT into one of their core product (the patient lifts) formed the basis for an intelligent PSS offering. This PSS aimed to leverage customer data to create awareness of the physical load that caregivers experience during patient transfer activities, helping organizations take action to prevent physical overload. The proposed solution gathers the aggregate data from one or multiple patient lifts, and presents the data to the customer in a SaaS solution, unlocking new value for healthcare (Aceto et al., 2020). This SaaS consists of weekly or monthly email reports, as well as an online portal for continuous monitoring. Moreover, through this proposed PSS, esense can potentially gain a closer relationship with their customers, by supporting them in their journey towards a safer and healthier work environment, rather than simply selling products. Thus, the outcome of this project agrees with previous findings (e.g. Aceto et al., 2020) that IoT can unlock value co-creation and a closer relationship with customers in the healthcare.

Moreover, in this research, it became evident that some healthcare professionals felt somewhat intimidated by the idea of IoT data collection, from a privacy standpoint. Several participants expressed that it is important that IoT does not feel like surveillance, but instead, that the caregivers are informed and actively involved with interpreting the data. This corresponds with Ng and Wakenshaw (2016) who argue that in order to reduce security and vulnerability concerns, firms must take action to improve security, as well as actively engage the customers with the IoT solution. Furthermore, in the HWaaS case, the decision was to only collect data on a team-level, rather than from individual users, which most participants approved of. Thus, this research argues that listening to the stakeholders' IoT-related concerns is a key part of designing for Healthcare 4.0, and an area where service design can help firms empathize with their customers.

11.3 Choosing an IoT-Enabled Servitized BM

Suppatvech et al. (2019) identified four BM archetypes for IoT-enabled servitization, including add-on , solution-oriented, sharing and usage BMs. Moreover, they suggested that the solution-oriented or add-on BMs could potentially be the most promising for manufacturing firms pursuing servitization, as IoT is deeply integrated in the value proposition. Moreover, since add-on BMs may be less complex than solution-oriented BM to achieve, add-on BMs are suitable first steps for manufacturers to take towards IoT-enabled servitization (Suppatvech et al., 2019). This matches the reasoning by Jovanovic et al. (2019) that organizations should take a sequential approach to servitization. Similarly, an add-on BM was found to be the most suitable to implement in the HWaaS context, since healthcare organizations are often locked into their patient lift investments for up to 10 years. Since the IoT-modules could be installed into the esense patient lifts that are already being used in the market, an add-on BM would allow esense to co-create value with existing customers. Thus, the outcomes of this research agreed with previous statements by Suppatvech et al. (2019) and Jovanovic et al. (2019) illustrating the implementation of add-on BMs through a PBDR case.

11.4 The Challenges of Innovating for Healthcare

It is commonly known that healthcare is an especially challenging service context for designers, due to a variety of reasons, including high complexity, scale, variety, interdependencies with clients, hierarchal structures, highly socio-technical settings, and its position in society (Robert & Macdonald, 2017). Moreover, healthcare legacy-systems might be resistant to technological adoption (Bronsoler, 2020; Plsek, 2003) where the status-quo sometimes works against those striving to introduce novel solutions (Rodrigues & Vink, 2016).

These aforementioned challenges were present in the HWaaS research as well. The participating healthcare organizations differed from each other, had varying internal processes for physical overload prevention, a hierarchal nature, and often consisted of large and complex stakeholder networks. Furthermore, many healthcare stakeholders expressed how their organizations, and individual actors within those networks, could be resistant to new technologies and behavior change. To convince a team to adopt a technology, thought leaders in a group first needed to be convinced, in order for the others to follow. These findings agree with Plsek (2003) who argued that service providers and manufacturers must be able to identify key thought leaders who will stimulate the diffusion of technologies. In the case of the HWaaS project, those individuals were the ergo coaches on a floor-level, as well as Arbo-Coordinators on a management level.

Previous authors advocated for the relevance of service design and design thinking in the healthcare domain (e.g. Carroll & Richardson, 2016; Clack & Ellison, 2019). In the HWaaS project, the human-centered approach to service innovation proved to be useful to help the researcher empathize with actors in the healthcare system, map their complex context, identify their pain points, and adapt the solution to fit their processes. Thus, this research strongly supports the implementation of the service design in service innovation for healthcare.

11.5 The Role of Service Design for IoT-Enabled Servitization in Healthcare 4.0 Context

Previous research has theorized that service design can help manufacturing firms move towards smart PSS (Solem et al., 2021). However, at the time of the thesis, few practice-based studies had been carried out in the intersection between service design and IoT-enabled servitization in the healthcare context. Therefore, this project deployed a Research Through Design (RTD) approach, to design an IoT-enabled PSS for a healthcare technology manufacturer, building upon the integration of IoT into one of their core products. Deploying service design tools and methods proved useful to uncover pain points and novel value co-creation opportunities with the healthcare organizations, leveraging IoT technology for a customized service offering, while also being attentive to key stakeholders attitude towards data collection and technology. Moreover, by deploying a holistic approach to service innovation, several key components necessary for service innovation were addressed, including employee knowledge, motivations, technologies and redesigning the underlying BM. Thus, this research provides a practice-based example of how service design can be implemented by manufacturing companies taking their first steps on their IoT-enabled servitization journey in the Healthcare 4.0 context.

11.6 Limitations of the Study

There are a number of limitations of this study. Firstly, since this project was carried out during the COVID-19 pandemic in 2021, in-context research together with the healthcare organizations was not possible. This may have limited the researcher's ability to fully understand the context in which the actors operate on a daily basis. Moreover, due to the high work pressure that was placed on healthcare professionals during this time, it proved difficult to recruit the stakeholders for this research, and especially the people at the heart of the project, namely: the caregivers. Although some caregivers were able to participate in the research, it can be assumed that a more detailed understanding of caregivers' needs, challenges and motivations could have been gathered with more participants.

Secondly, this research intended to investigate the creation of a new IoT-enabled PSS, which is desirable, feasible and viable. However, although the desirability was explored in detail throughout the research, the feasibility and viability of the suggested BM was mostly discussed in the modeling of a future BM. Therefore, in the esense HWaaS case, conducting more detailed analysis regarding the financial viability and technological feasibility of the project is encouraged.

Thirdly, the research conducted in this project was qualitative, which means that the interpretations of the data is inevitably subjective. Since the research was mainly conducted by a one master thesis student, supported by an innovation coordinator from Wordlenig, these two perspectives were highly formative for the outcome of the research. Therefore, for continued research, a larger group of researchers is recommended.

Lastly, this project focused largely on crafting a PSS that was anchored in stakeholder needs, leveraging an IoT-enabled BM. However, the challenges regarding how to achieve data security were not deeply investigated in this project. Since having high data management competencies is core for manufacturers exploring IoT-enabled solutions (Suppatvech et al., 2019), esense, as well as other firms exploring a similar servitization path, are encouraged to research this further.

11.7 Future Recommendations

This study was, to the knowledge of the author, one of the few examples of PBDR conducted to explore the role of service design in helping manufacturing companies deploy a service design approach to IoT-enabled servitization. Thus, the author hopes to inspire further research in this field. Moreover, there is interesting overlap happening in both design thinking, as well as service design. This research has shown how service design can be viewed as the application of design thinking to the service domain, as previously mentioned by e.g. Clatworhty (2017). Future research may wish to investigate this relationship further, to establish more synergy between these two fields.

12. Conclusion

This research aimed to explore the role of service design in IoT-enabled servitization, for manufacturers targeting the Healthcare 4.0 context. By deploying a Research Through Design (RTD) approach to Practice-Based Design Research (PBDR), an IoT-enabled PSS was designed for the healthcare technology manufacturer esense, building upon the integration of IoT into one of their core products. Deploying service design tools and methods proved useful for uncovering novel value co-creation between esense and their customers, and for inviting the healthcare professionals to become more engaged with IoT. This research provides and example of how service design can be implemented by manufacturing companies taking their first steps in their IoT-enabled servitization journey, transitioning towards increased customer-centricity in manufacturing.

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Appendix A

A1 Add-On BM Types

Suppatvech et al. (2019) mention four different types of Add-On IoT-enabled servitized BM:

1. **Innovative Digital Service BM:** Creates a hybrid product-service offering, by linking a digital service to a product with integrated sensors, e.g. a wearable fitness tracker with additional app.
2. **Facilitating Service Provision BM:** Makes existing product or service offerings more efficient, or less complex, e.g. using IoT to streamline customer orders in a B2B setting.
3. **Leverage Customer Data BM:** Collects data during usage from the customer, from which a customised service offering is crafted, e.g. smart washing machines with monthly data reporting.
4. **On-Demand BM:** Makes the additional service or information is made available upon customer request.

A2 Usage BM Types

Suppatvech et al. (2019) mention two different types of Usage-Based IoT-enabled servitized BM:

1. **Pay-Per-Use BM:** The customer is charged according to their actual usage, based on the IoT measurements.
2. **Subscription BM:** The customer pays for an unlimited access to the service.

A3 Solution-Oriented BM Types

Suppatvech et al. (2019) mention two different types of Solution-Oriented IoT-enabled servitized BM:

1. **Availability BM:** Makes a promise to the customer of continuous use of a product or service that delivers certain utility, without any disruptions. IoT technology monitors the status of the product or service and communicates

if maintenance or other forms of service is needed, presented by the service provider.

2. **Optimization or Consulting BM:** The service provider monitors and analyzes the customer's usage data and provides advice on how the customer can optimize their operations.

Appendix B

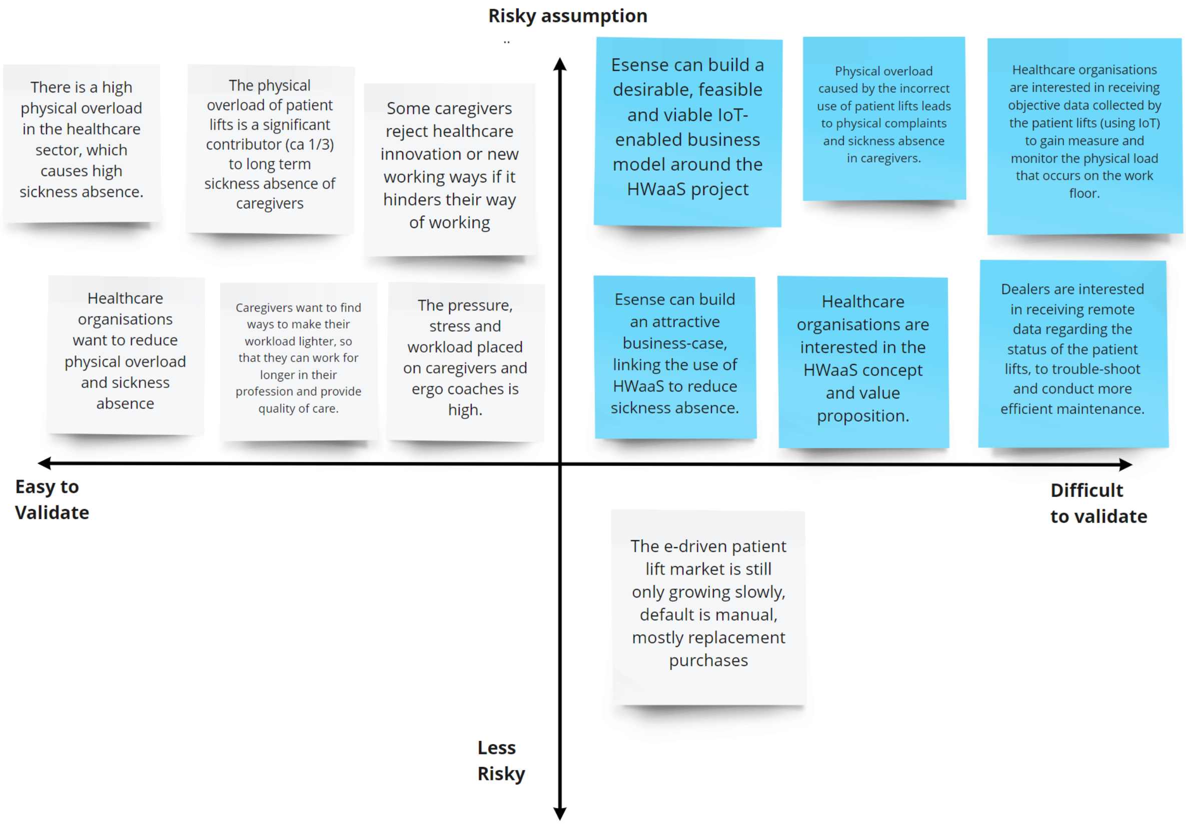
About EU-OSHA

On a European level, the European Union information agency for occupational safety and health (EU-OSHA) works to improve working conditions in Europe (Dutch Working Conditions Legislation, 2017). Each member state of the European Union has an appointed 'Focal Point' organisation, that works to implement programmes from the EU-OSHA, as well as share information about OSH between countries. The Netherlands Focal Point (NL-FOP), representing EU-OSHA, strives to import and export information and best practices regarding occupational health. NL-FOP is managed by TNO (the Netherlands Organisation for applied scientific research), in consultation with the government, employers and employees. Many rules in the Netherlands regarding working conditions draw from European directives, including the EEC Safety and Health at Work Framework Directive (89/391/EEC).

Appendix C

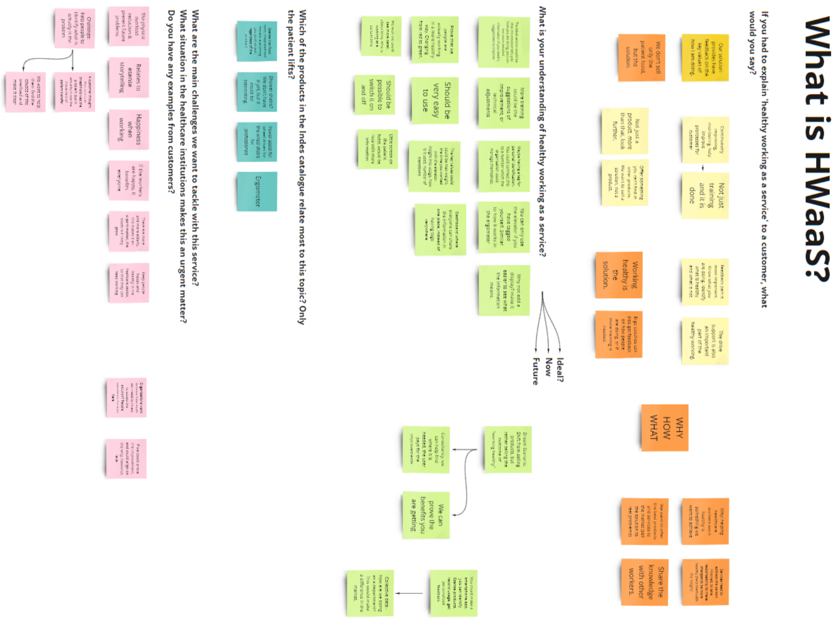
Initial Assumption Map

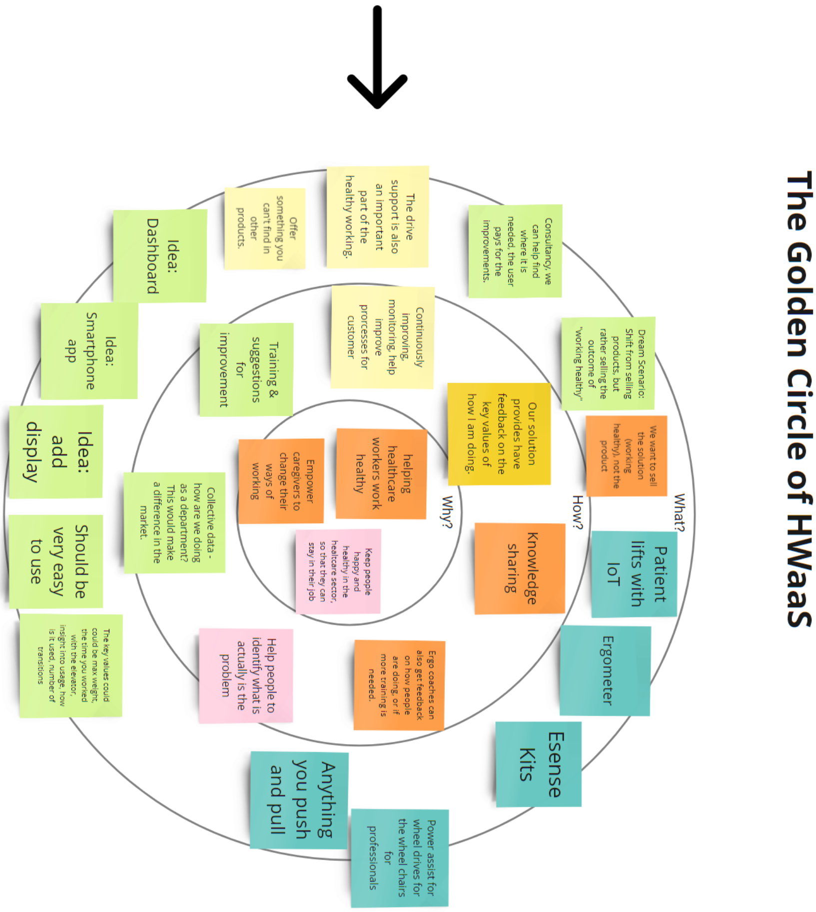
Assumption maps help organizations make assumptions regarding the desirability, viability and feasibility of a project explicit (Bland, 2020). The map has two axes: 'Riskiness' and 'Difficulty to Validate'. The most risky and difficult and validate assumptions are called the 'Riskiest Assumptions' (top right corner), and illustrate the assumptions which the team should focus on validating through experimentation.



Appendix D

HWaaS Motivation Workshop





Appendix E

E1 Current BM Canvas

The current business model canvas, adopted from Osterwalder and Pigneur (2010).

Current Business Model

KEY PARTNERS

Dealers

KEY ACTIVITIES

Collaborate with dealers

Ergometer test

R&D

Low Marketing

KEY RESOURCES

Integrated software and hardware solution

Relationships with customers and partners

User experience

Knowledge

VALUE PROPOSITION

Easy-to-maneouver patient lifts which are intuitive, and reduce the physical load placed on the caregiver

Beautiful and comfortable design

Patient lift that informs about physical load exerted during use (ergo feedback)

CUSTOMER RELATIONSHIPS

Mainly via dealers

CHANNELS

Dealers

Ergometer tests

Social media

Word of mouth

CUSTOMER SEGMENTS

Healthcare organisations that conduct patient transfers (mainly nursing homes for elderly or disabled people)

Replacement purchases (95%)

Specifically looking to improve healthy working (5%)

COST STRUCTURE

R&D

Salaries

Marketing

Logistics

Production

REVENUE STREAMS

Fixed price for patient lifts, dealer re-sells the lift and receives a percentage of the customer price

E2 Identified Weaknesses in Current BM

Table E2. Analysis of the strengths and weaknesses in the existing esense BM

<table>
<tr><th>Part of BM Canvas</th><th>Weakness</th><th>Opportunity</th></tr>
<tr><td>Customer Segment</td><td>Esense is currently mainly making replacement sales.</td><td>Target innovative organizations for HWaaS, that are focused on reducing physical overload.</td></tr>
<tr><td>Value Proposition</td><td>The ergonomic data is collected by lift and ergometer, is not easily accessed afterwards</td><td>Collect ergonomic data, unobtrusively, that is easily accessible</td></tr>
<tr><td>Revenue Streams</td><td>The sales are one-off, not recurring revenue streams</td><td>Create recurring revenue streams through servitized BMs</td></tr>
<tr><td>Channels</td><td>Dealers rarely use the ergometer & full ergometer report</td><td>Make ergonomic data more easily available</td></tr>
<tr><td>Customer Relationship</td><td>Very little marketing or promotion occurs actively towards the customer</td><td rowspan="3">Make direct connection with customer through service provision</td></tr>
<tr><td>Key Activities</td><td>Low direct marketing activities</td></tr>
<tr><td>Key Partners</td><td>Esense relies on dealer for sales, and therefore has little direct connection to customer</td></tr>
<tr><td>Key Resources</td><td>Brand is not a main asset (low awareness)</td><td>Strengthen Esense position in market as pioneers in ergonomic monitoring</td></tr>
</table>

Appendix F

Analysis of Customer Journey

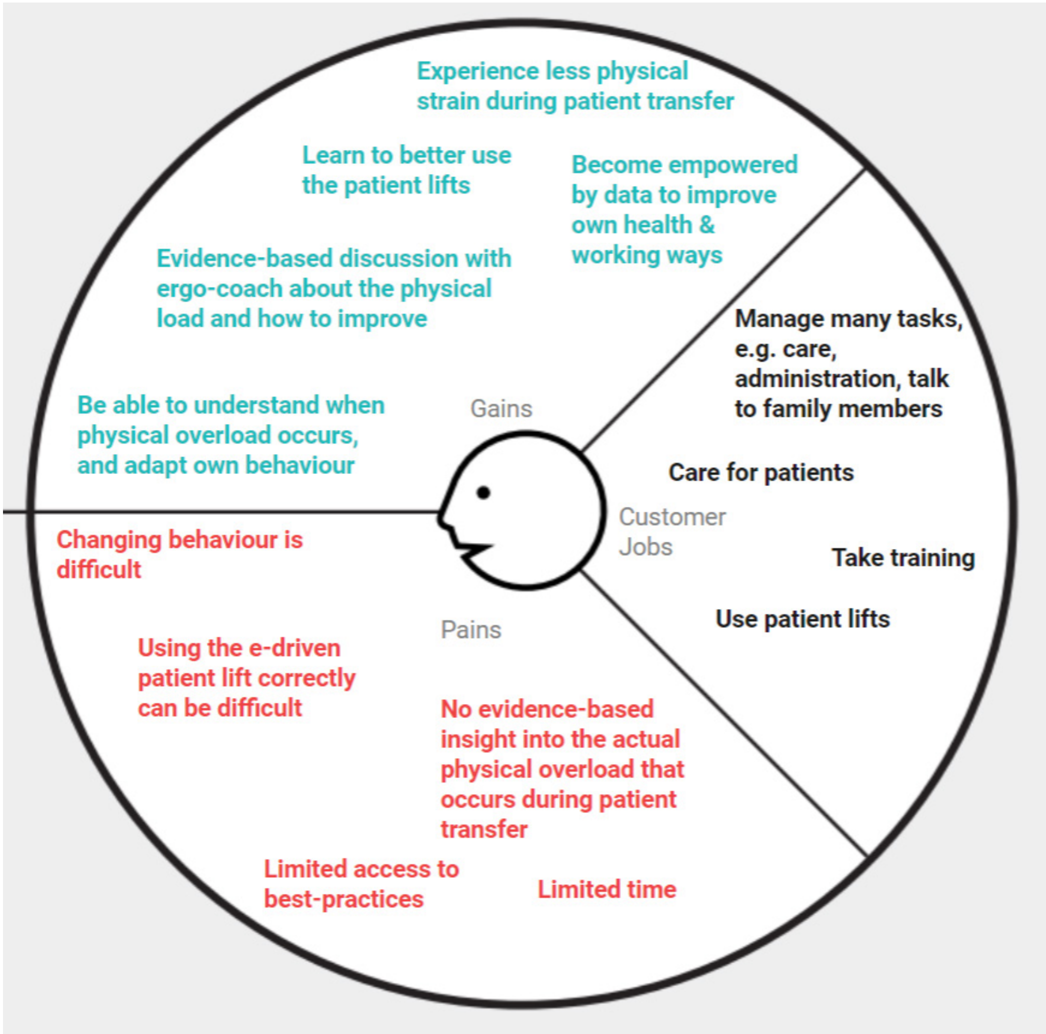
Table F1. Weaknesses and opportunities identified in the Customer Journey Mapping exercise.

Part of Customer Journey	Weakness	Opportunity
Awareness	In the awareness phase, esense is largely reliant on the dealer to make sales, and the brand awareness in the target group is low	More direct promotion and marketing activities could help esense boost sales
Trial Period	Healthcare professionals sometimes struggle with using the e-driven lift	Collect ergonomic data, unobtrusively, that is easily accessible
Use	Some caregivers struggle to learn how to use the lift correctly	
Follow-Up	Esense is not always involved in the follow-up	Closer collaboration with dealers

Appendix G

G1 Caregiver Empathy Map

The empathy map part of the Value Proposition Canvas, adopted from (Strategyzer, 2020).



G2 Caregiver Persona

Birgit van Dijk

Caregiver

Age: 64 years old
Nationality: Dutch
Location: Hengelo
Status: Married
Children: 3 children (grown up)
6 grandchildren
Education: Verzorgende IG

"The e-driven patient lift is too hard to use, that is why I tend to choose the manual lift we have in our department. Then you don't have to wait for it to activate, you can just get started straight away"

Jobs-to-be-done:
- Transfer client safely
- Manage and execute many care tasks
- Complete training
- Learn how to use available tools
- Take responsibility for own health

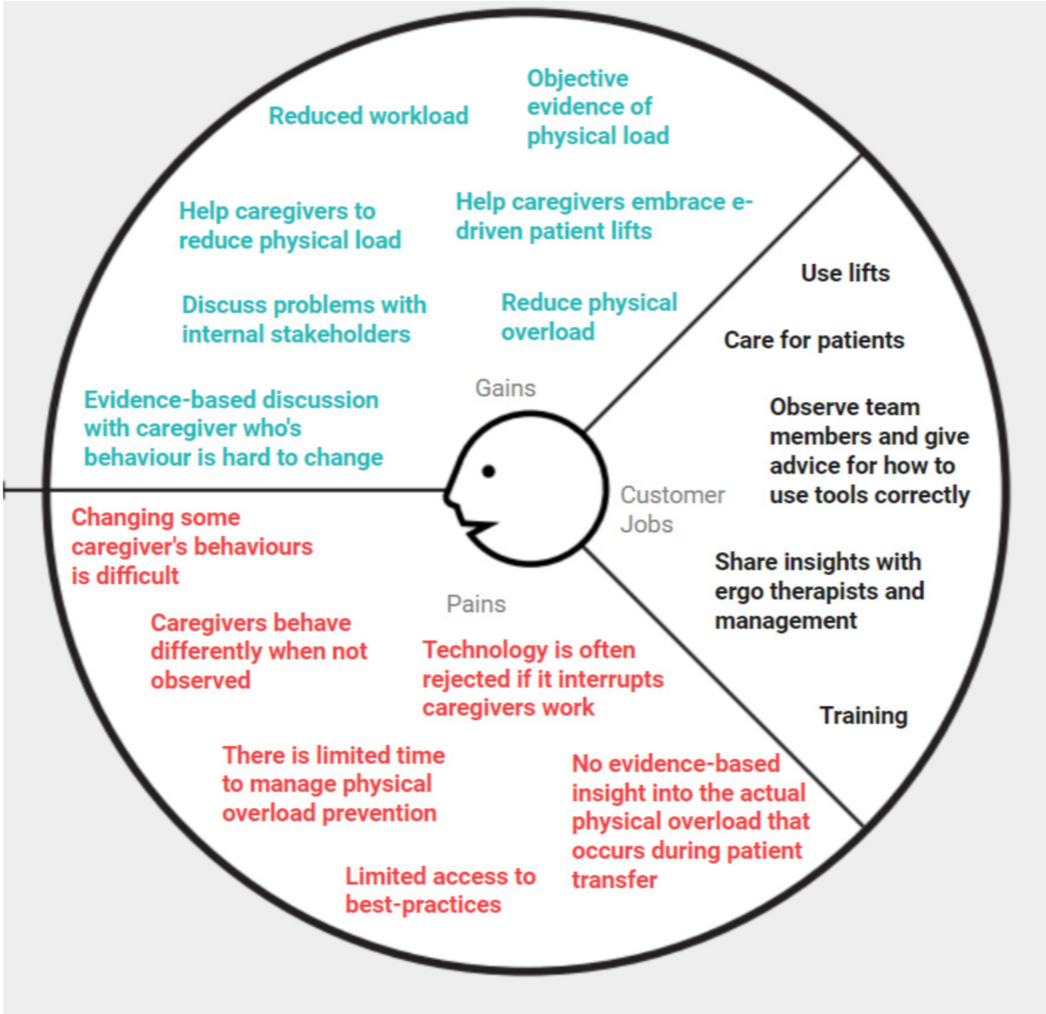
Motivations:
- Bonding with client
- Giving the best care
- Spending time with grandchildren

Pains:
- Finds e-driven annoying to use
- E-driven takes too long to start up
- Behaviour is hard to change
- Under a lot of pressure at work
- Experiencing long-term shoulder pain
- No actual insight into physical load

Gains:
- Less physical strain during transfer
- Learn to better use the lifts
- Become empowered by data to improve
- Evidence-based discussion with ergo-coach
- Get insight into physical overload

G3 Ergo Coach Empathy Map

The empathy map part of the Value Proposition Canvas, adopted from (Strategyzer, 2020).



G4 Ergo Coach Persona

Sophie Provoost

Ergo Coach

Age:	31 years old
Nationality:	Dutch - German
Location:	Enschede
Status:	Lives with boyfriend
Children:	No
Education:	Verzorgende IG + Ergo-coach course

“I always try to encourage my team to use the tools correctly. Most of my colleagues listen, but in this one department, it is more difficult. Whenever I am not looking, they fall into old habits.”

Jobs-to-be-done:
- Transfer client safely
- Manage and execute many care tasks
- Observe colleagues
- Train colleagues how to use tools
- Report injuries and problems to mgmt
- Take responsibility for own health

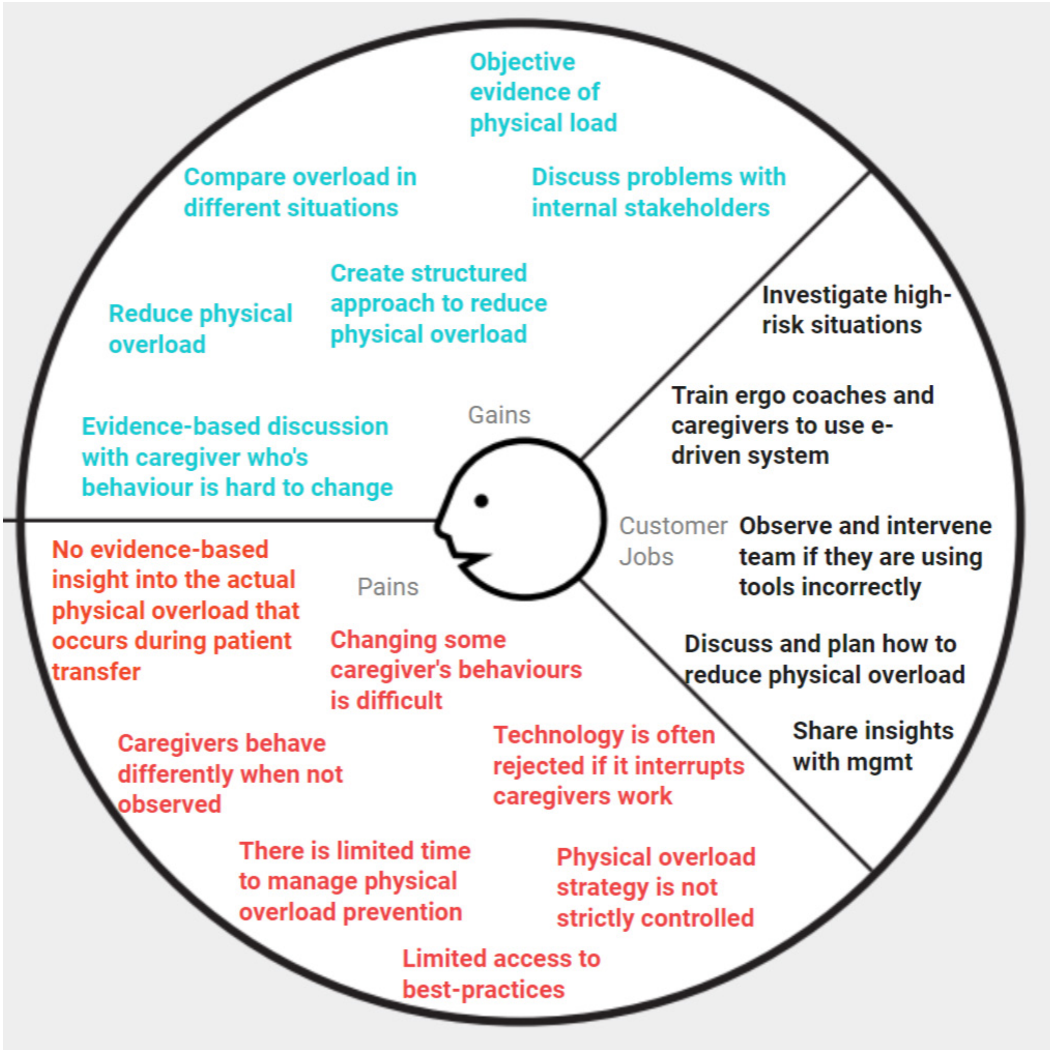
Motivations:
- Help team become healthier
- Giving the best care to the clients
- Having a cup of coffee with colleagues
- Spending time with her friends

Pains:
- Hard to monitor team & patient
- High work pressure, little time
- Changing caregiver’s behaviour is difficult
- No objective insight into physical overload

Gains:
- Less physical strain during transfer
- Evidence-based discussion with team
- Get insight into physical overload
- Help caregivers reduce physical load
- Help caregivers use tools correctly
- Measure impact of training

G5 Occupational- & Physiotherapists Empathy Map

The empathy map part of the Value Proposition Canvas, adopted from (Strategyzer, 2020).



G6 Occupational- & Physiotherapists Persona

Coen Bakker

Occupational Therapist

Age: 37 years old
Nationality: Dutch -
Location: Almelo
Status: Single
Children: No
Education: HBO diploma in Ergotherapie

"My team is under a lot of pressure, and I want to help them have a healthier way of working. But that can be hard sometimes, they don't always listen."

Jobs-to-be-done:
- Train colleagues how to use tools
- Observe & coach team
- Discuss and make care plans
- Investigate high-risk situations
- Communicate with arbo & mgmt

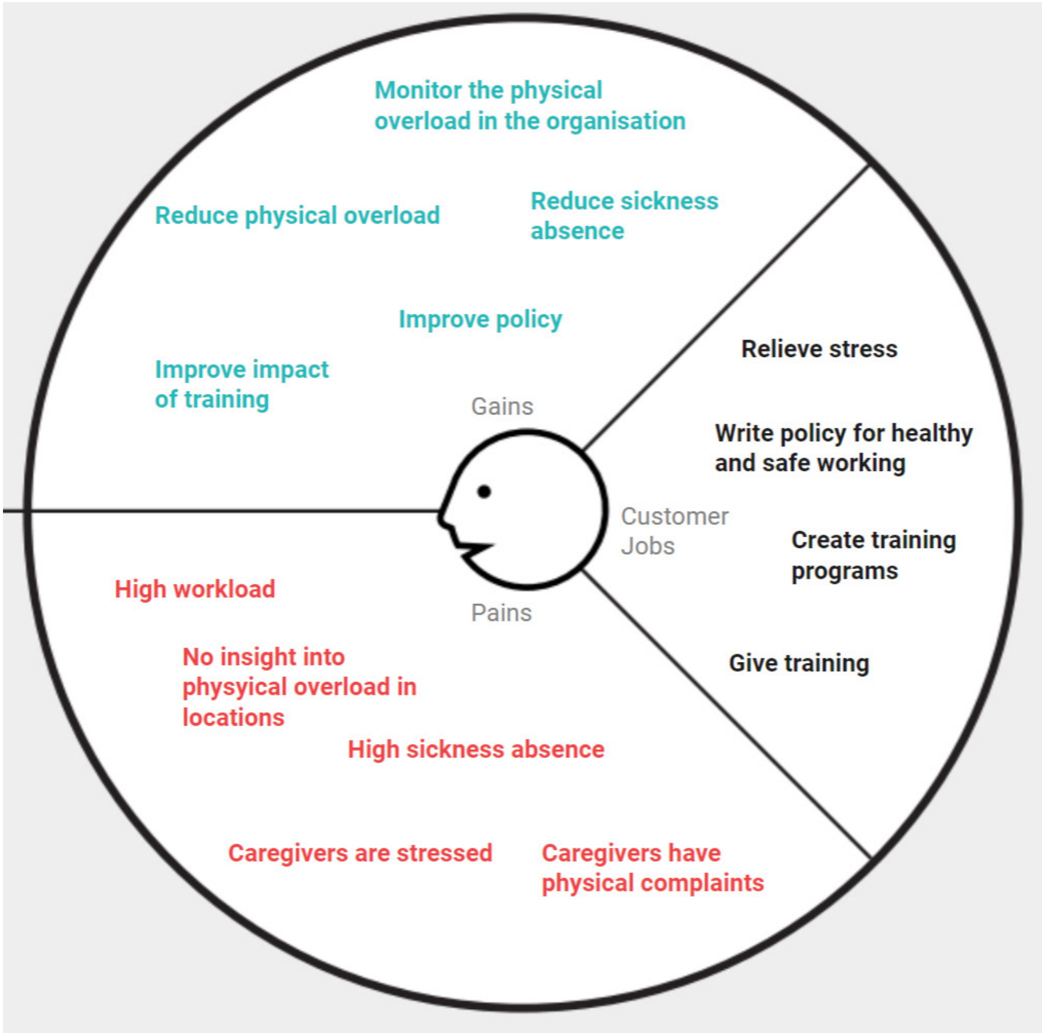
Motivations:
- Help team become healthier
- Help clients stay active and mobile
- Learning more about her profession

Pains:
- No insight into the physical load experienced by the tam
- Caregivers behave differently when she is not there
- Some caregivers don't want to use e-driven
- Limited time

Gains:
- Less physical strain during transfer
- Evidence-based discussion with team
- Get insight into physical overload
- Help caregivers use tools correctly
- Measure impact of training
- Get evidence to motivate investing in new technologies and aids

G7 Arbo-Coordinator Empathy Map

The empathy map part of the Value Proposition Canvas, adopted from (Strategyzer, 2020).



G8 Arbo-Coordinator Persona

Marloes Van de Berg

Arbo-coordinator

Age:	51 years old
Nationality:	Dutch
Location:	Hengelo
Status:	Living with boyfriend
Children:	1 child
Education:	HBO diploma in Physiotherapy + Arbo-coordinator education

"I strive to develop policies and trainings that help our organisation provide safe, healthy and happy working conditions for our employees. An important part of this is to reduce physical overload."

Jobs-to-be-done:
- Write policy for safe & healthy working
- Stay up-to-date regarding arbo regulation
- Develop training
- Give training
- Participate in healthy working group

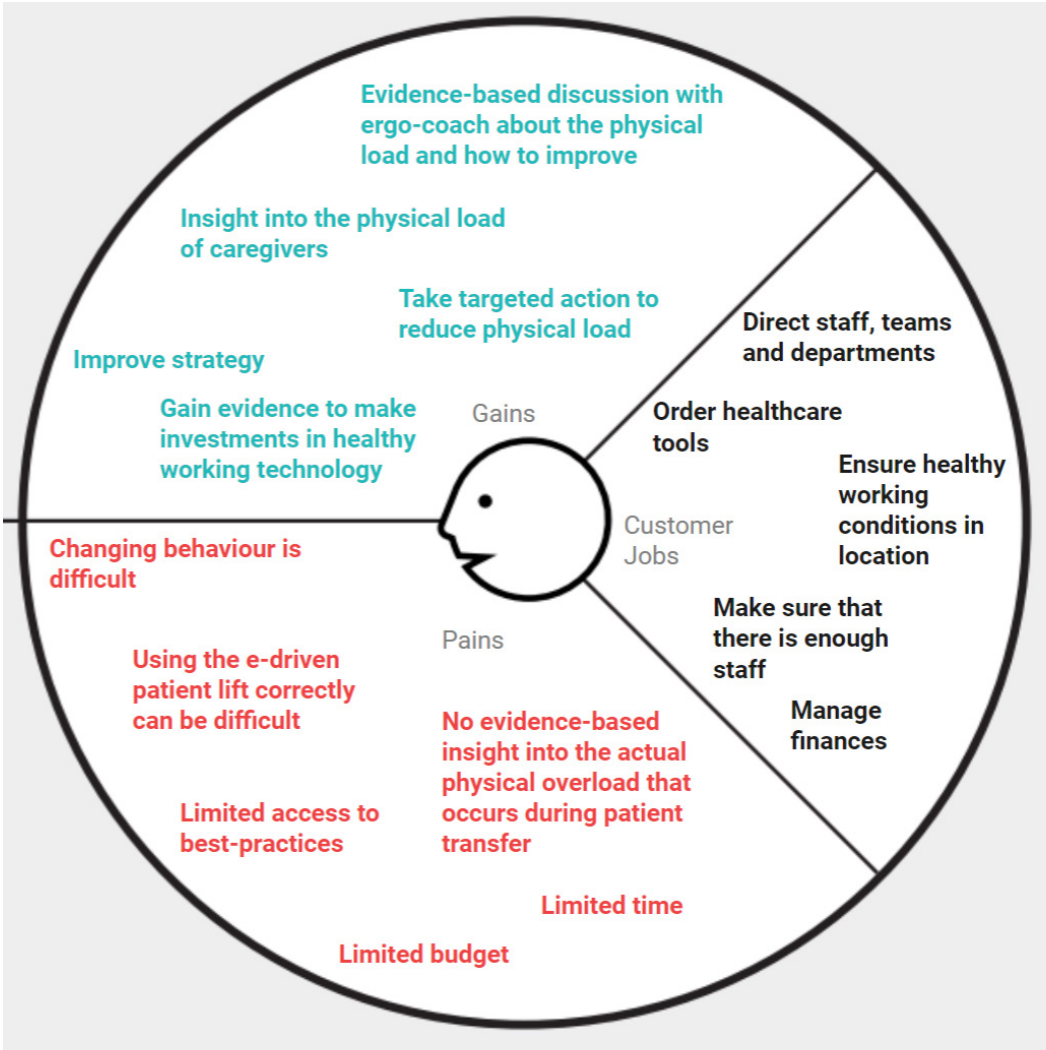
Pains:
- No insight into the physical overload in locations
- No way to measure impact of tranings
- No structured way to control physical overload prevention process
- High sickness absence and physical complaints among caregivers

Motivations:
- Create a safe and happy working environment
- Help caregivers stay longer in their professions
- Reduce sickness absence

Gains:
- Evidence-based discussion with team
- Evaluate impact of training
- Take targeted action
- Improve policy and strategy
- Reduce physical overload and sickness absence

G9 Location Manager Empathy Map

The empathy map part of the Value Proposition Canvas, adopted from (Strategyzer, 2020).



G10 Location Manager Persona

Mona Verbraak

Location Manager

Age: 55 years old
Nationality: Dutch
Location: Almelo
Status: Married, 2 children
Children: No
Education: HBO Verpleegkundig
Master Zorgmanagement

"My goal is to get the sickness absence in my location down."

Jobs-to-be-done:
- Ordering the patient lifts to be procured (in collaboration with team and the dealer)
- Ensuring that there is enough staff to care for the clients
- Recruit more staff if needed
- Managing finances for the location

Motivations:
- Provide high level of care to clients
- Ensure that team is happy and healthy
- Reduce sickness absence

Pains:
- No insight into the physical load experienced by the tam
- Some caregivers don't want to use e-driven
- There is high sickness absence in her location
- It is hard to find enough staff to cover all the shifts

Gains:
- Get insight into physical overload in location, to make better decisions and investments
- Help caregivers use tools correctly
- Measure impact of training
- Get evidence to motivate investing in new technologies and aids

Appendix H

Stakeholder Participant List

Participant Nr	Role	Interview 1	Prototyping Session
P1	Arbo-Coordinator Physiotherapist	Yes	Yes
P2	Occupational therapist	Yes	Yes
P3	Dealer	Yes	
P4	Physiotherapist	Yes	Yes
P5	Innovation Coordinator	Yes	Yes
P6	Ergonomic Advisor & Sales	Yes	
P7	Board Member	Yes	
P8	Caregiver Ergo Coach	Yes	Yes
P9	Caregiver Ergo Coach	Yes	
P10	HR Advisor	Yes	Yes
P11	Physiotherapist		
P12	Ergonomic expert		Yes
P13	Caregiver Ergo Coach		Yes

Appendix I

I-1 Affinity Diagram

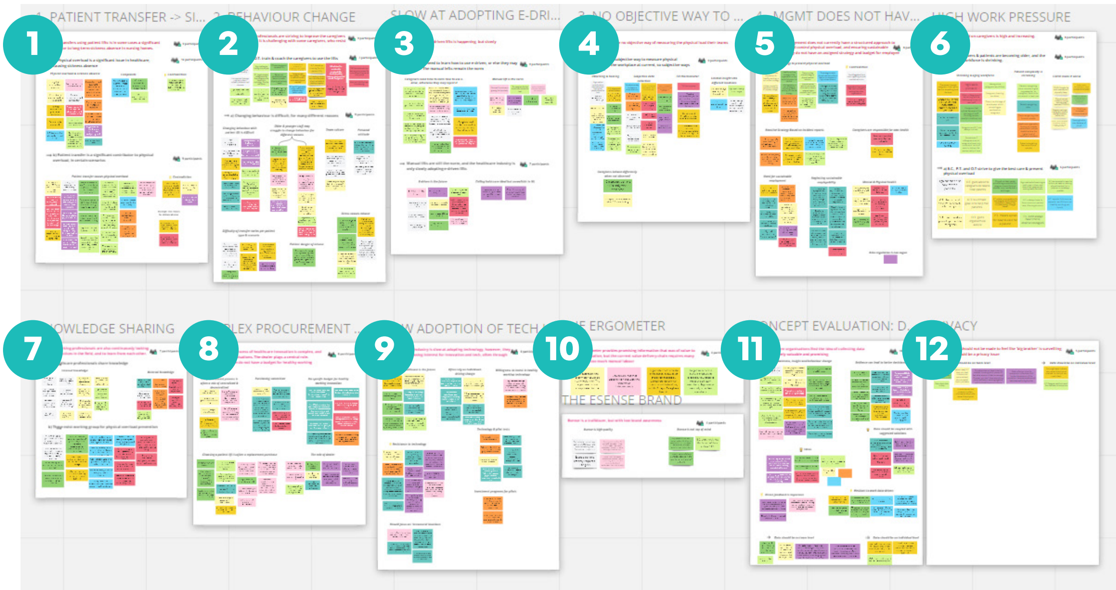


Figure I1: Screenshot showing the digital affinity mapping results.

1. Patient transfer is a cause of physical overload in healthcare, but it is not possible to say exactly how much

2. Caregivers need to adopt healthy behaviors with the patient lifts, but behavior can be hard to change

3. The Healthcare Industry is Slow at Adopting E-driven Lift

4. There is currently no objective way to measure the physical load their teams are experiencing.

5. Healthcare organization's often do not have a clear strategy for physical overload prevention and sustainable employability

6. The pressure placed on caregivers is high and increasing

7. Ergonomic professionals seek knowledge sharing opportunities & best practices

8. The procurement process of healthcare innovation is complex and differs between organizations

9. Although healthcare industry is slow at adopting technology, they are increasingly interested

10. The ergometer is insightful but too complicated in practice

11. Esense is a trailblazer, but with low brand awareness

12.Healthcare organizations find the idea of collecting data promising, but data is not everything, and privacy could be an issue

I-2 Tallied Responses from Interview

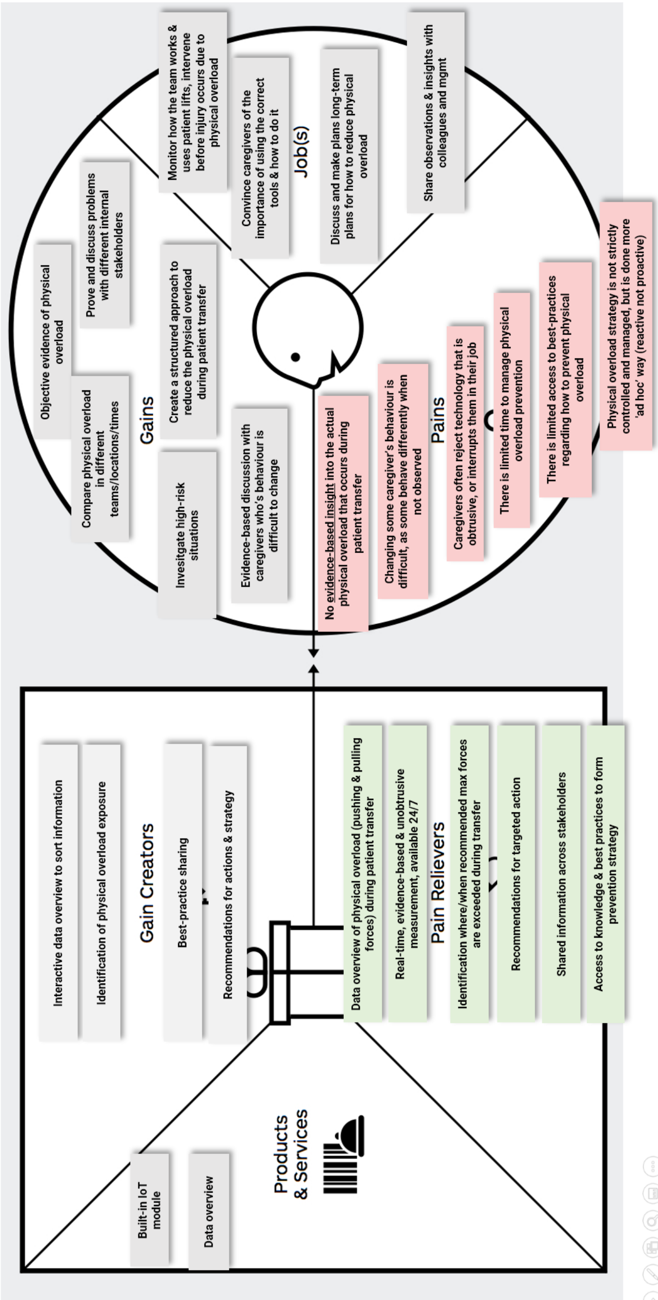
Table 1-2. Tallying the responses from the interview. P1 refers to Participant 1, etc. The number of participants validating each statement is shown, which is translated into a (qualitative) evidence strength score. +++ = at least 6 participants, ++ = at least 4 participants, + = at least 1 participant, +/- =conflicting opinions.

	Insight	Validated by	Evidence Strength
1	Patient transfer is a cause of physical overload in healthcare, but it is not possible to say exactly how much	9/12	+++
2	Caregivers need to adopt healthy behaviours with the patient lifts, but be-haviour can be hard to change	9/12	+++
3	The Healthcare Industry is Slow at Adopting E-driven Lifts	9/12	+++
4	There is currently no objective way to measure the physical load their teams are experiencing.	9/12	+++
5	Healthcare organisation's often do not have a clear strategy for physical overload prevention and sustainable employability	8/12	+++
6	The pressure placed on caregivers is high and increasing.	8/12	+++
7	Ergonomic professionals seek knowledge sharing opportunities & best practices	7/12	+++
8	The procurement process of healthcare innovation is complex and differs between organisations	6/12	+++
9	Although healthcare industry is slow at adopting technology, they are in-creasingly interested	6/12	+++
10	The ergometer is insightful but too complicated in practice	4/12	+
11	Esense is a trailblazer, but with low brand awareness	4/12	+
12	Healthcare organisations find the idea of collecting data promising, but data is not everything, and privacy could be an issue	10/12	+++

Appendix J

Value Proposition Canvas

The Value Proposition Canvas, adopted from (Strategyzer, 2020).



Appendix K

K1 Protocol for Prototyping Session

60 mins, online: google meets, miro & figma

Introduction:

Thank you for joining us today, we really appreciate your feedback. The goal of today is for us to understand your process for physical overload prevention during patient transfer a bit better, as well as to get your feedback and thoughts on our prototype.

Ask for verbal consent to collect data (anonymously) and video record the conversation

Order of session:

- First 1 co-creative exercise using miro (send link)
- Next review prototype

Part A: Co-creation of journey map for internal process

10 mins / 60 mins

Introduction

This experiment will take place during the first part of a 1 h interview and will occupy approximately 10 minutes. The participant will be shown a pre-filled in overview of their stakeholder network (based on the first interview), and will be asked if it is correct or not, and how we can update it.

Research Question: What is the internal process that the organizations undergo to monitor, manage and reduce physical overload?

Part B: Testing Prototype

30 mins

Protocol: This experiment will take place during the second part of a 1 h interview and will occupy approximately 30 minutes of the session. The participant will be asked to review our prototype in the preview in Figma and imagine where it can fit into their internal process. They will be encouraged to 'speak-aloud' their thoughts and impressions.

Before showing the prototype, the interviewer 'sets the stage' with a small scenario.

Part C: Evaluation Questions

20 mins

Protocol: The interviewer will ask mainly open-ended questions in the final semi-structured interview. These questions are included below.

Usage

- What were your first impressions?
- Would you use this? In what scenarios would you use this information?
- Which data would you use first and why?
- Would you use it tomorrow?
- How would your work change if you had this tool?

Value

- What impact will this solution have on your tasks and responsibilities?
- Does this solution help you to control the quality of physical overload prevention?
- Is the data valuable enough on it's own, or would you need other supporting features (e.g. talking to an expert)? If so, what kind of support?

Format

- Are emails & an online dashboard a good way to view this data? How often?
- Would you want to receive the alerts via email every time recommended forces are exceeded?

Target group

- Who would be interested in this data?

Risk

- What do you foresee as the biggest challenges to deploying this solution in the company?
- What do you perceive as the weakest aspects of this solution?

Appendix L

L1 Tallied List of Feedback from Prototyping Session

Table L1. Tallying the responses based on stakeholder feedback during the prototyping session. P1 refers to Participant 1, etc.

Themes	P1	P2	P4	P5	P8	P9	P10	P12	P13
Users want to be able to see when and where an ergo alert happens, and what kind of movement & magnitude, to be able to analyse what is happening	+	+	+	+	+	+	+	+	+
Users want to see a yearly overview	+	+		+	+	+	+	+	+
Users liked the information about the differences between the teams and want to be able to see more detailed information about this.	+		+		+	+	+		+
Naming the lift according to the department makes sense. Esense can ask the location where they use the patient lifts during onboarding.	+	+		+	+	+			+
Information about when the transfer happened needs to be more accessible on the dashboard. Most participants found this information in the email alert.	+		+		+	+	+		+
The users want to be able to opt out of the ‘email alert’ or adapt the frequency.	+	+	+	+		+			
The ‘look and feel’ is nice and appropriate		+		+	+	+			+
Industry benchmarking is unnecessary, and not really that interesting		+	+	+		+	+		

Themes	P1	P2	P4	P5	P8	P9	P10	P12	P13
Users would like to link the type of patient to the data	+	+		+			+		
It is sufficient to display the time and location of the incident on a team level, not individual people, to protect privacy	+	+	+			+			
Daily overview is good because you can see when things happen				+	+	+			+
It is good that you focus on the healthy statistics, and not just focus on the bad statistics!	+	+		+				+	
Showing the time & location of the alert, could feel like big brother is watching over you, and maybe go against GDPR, but users are not sure.	/	/	/			/			
The team should be actively involved (e.g. given access to this software, and give consent before using it).	+	+	+						
It would be nice to see if you could compare this data to e.g. change in patient population, sickness absence, nr of replacement staff, etc. E.g. download as excel sheet.	+			+			+		
Healthcare organizations could imagine this being an interesting paid service, if it is not too expensive	/			+		+			

L2 Assumption Evaluation - Prototyping Session

Table L2. Evaluation of the 'Riskiest Assumptions' based on stakeholder feedback during the prototyping session. P1 refers to Participant 1, etc.

	Themes	P1	P2	P4	P5	P8	P9	P10	P12	P13
6	Customers find the data presented valuable to improve their internal physical overload prevention process	+	+	/	+	+	+	/	+	+
7	It is sufficient for healthcare organizations to receive aggregated data on a team level, not on individual level, to protect caregiver privacy.	+	+	+	+	+	+	+	+	+
8	Customers find the way the data is presented (email and dashboard) to be appropriate for them to integrate in their way of working	+	+	+	+	+	+	/	+	+
9	Aside from the data, users wish to have supportive features to help caregivers use the patient lifts correctly.	+	-	+	+	+	+	/		+
10	Healthcare organizations with high interest in physical overload prevention and innovation are the target 'early adopters' for the HWaaS project, and show interest in integrating the HWaaS solution in their organisation.					+	+			
11	Ergo coaches want to receive an automated email when physical overload is detected in their team.	/	-	-	-	+				+

L3 Stakeholder Roles Interest in Data

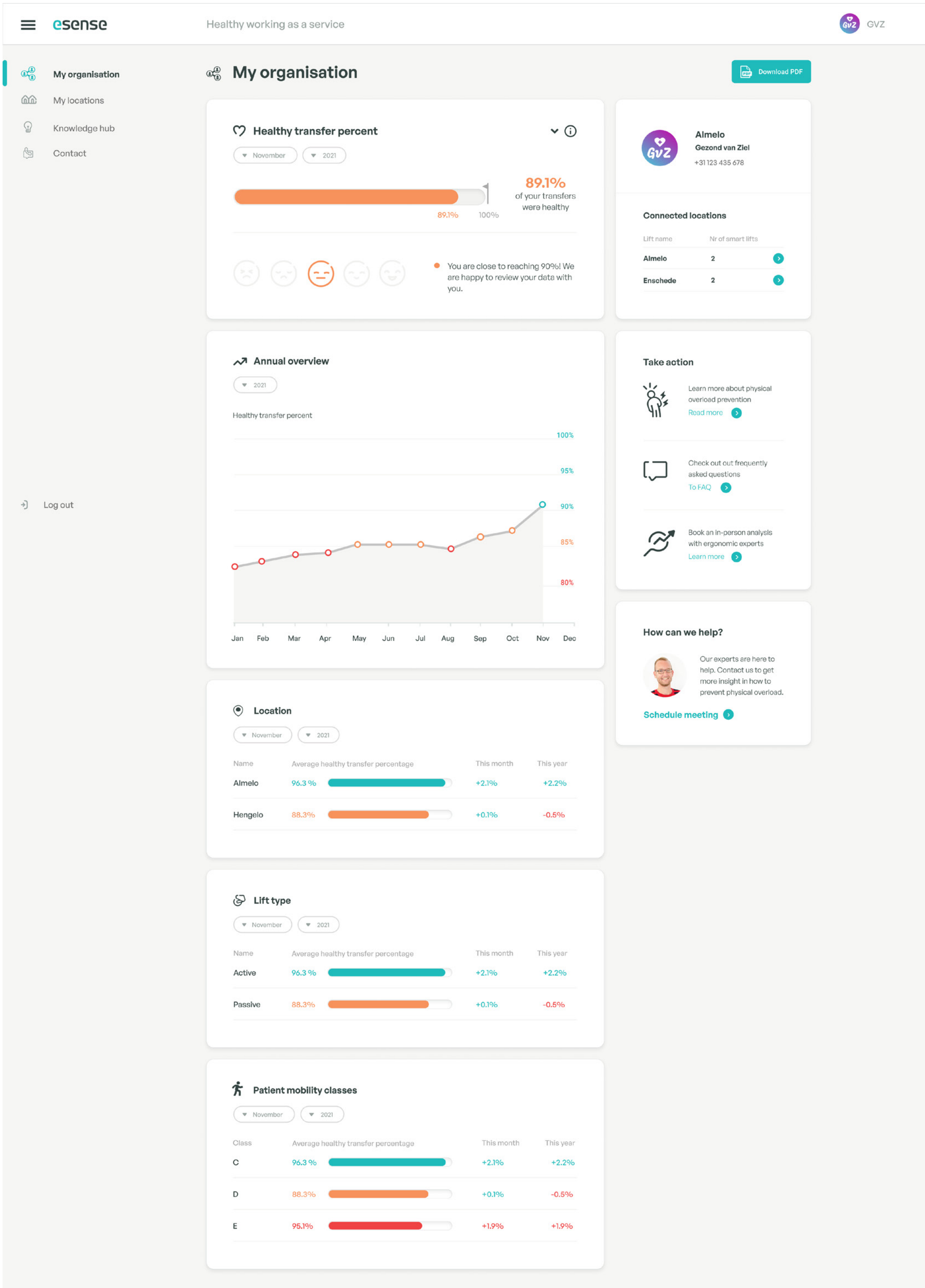
Tallied list of responses.

Table L3. Participant responses to the question regarding who would be the most interested in the data presented in the service prototype. P1 refers to Participant 1, etc. EC = Ergo Coach, LM = Location Manager, AC = Arbo-Coordinator, PO = Policy Officer, HR = Human Resources, OT = Occupational Therapist, PT = Physiotherapist

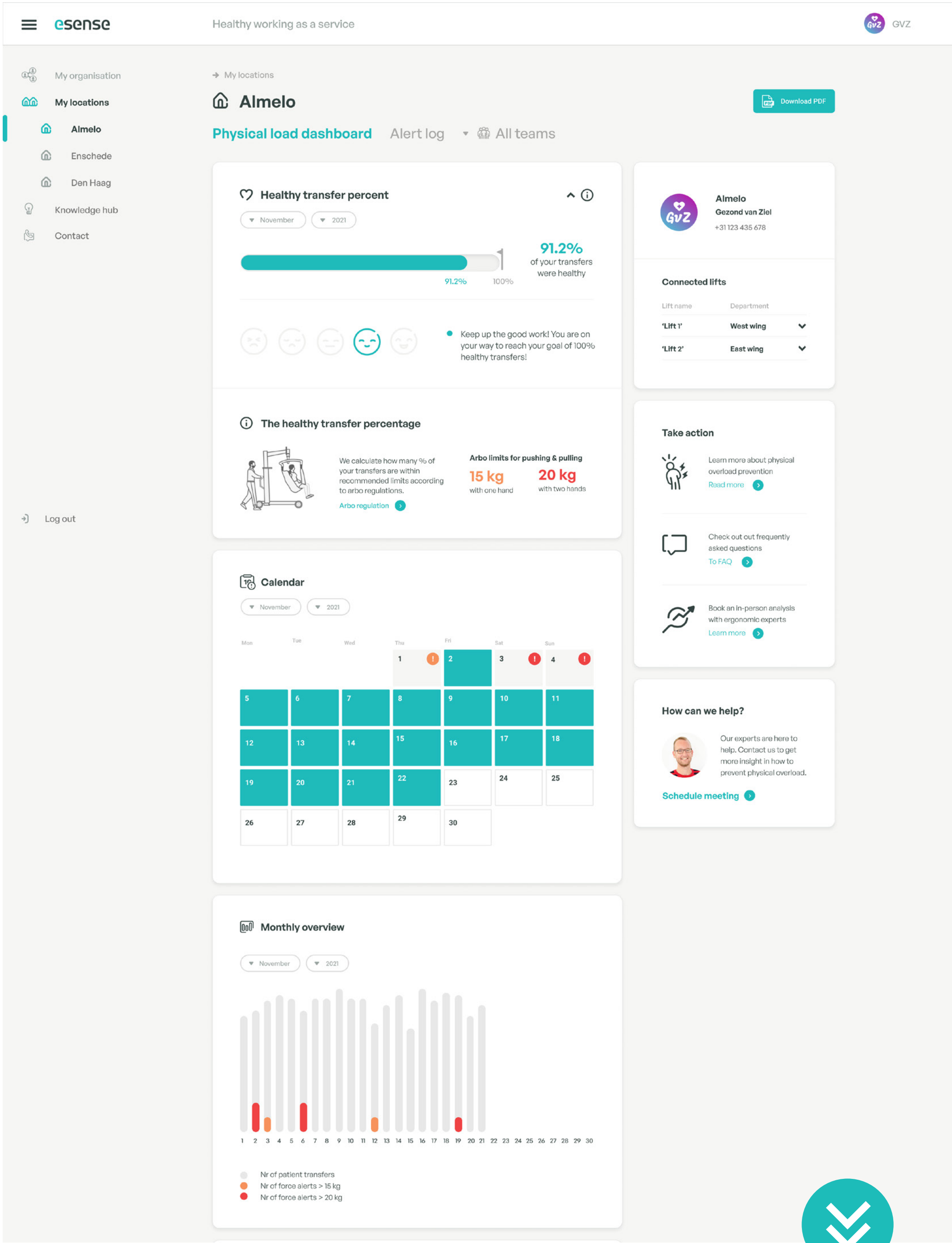
Question	P1	P2	P4	P5	P8	P9	P10	P12	P13
Who is the most interested in this data in your organization?	EC	EC	EC	EC	EC	EC	EC	EC	EC
	LM	LM	LM		LM	LM			LM
	AC	AC	AC	AC			AC	AC	
			HR				HR		
					OT		OT		
					PT		PT		
		PO							

Appendix M

M1 Future HWaaS Platform - ‘My Organisation’



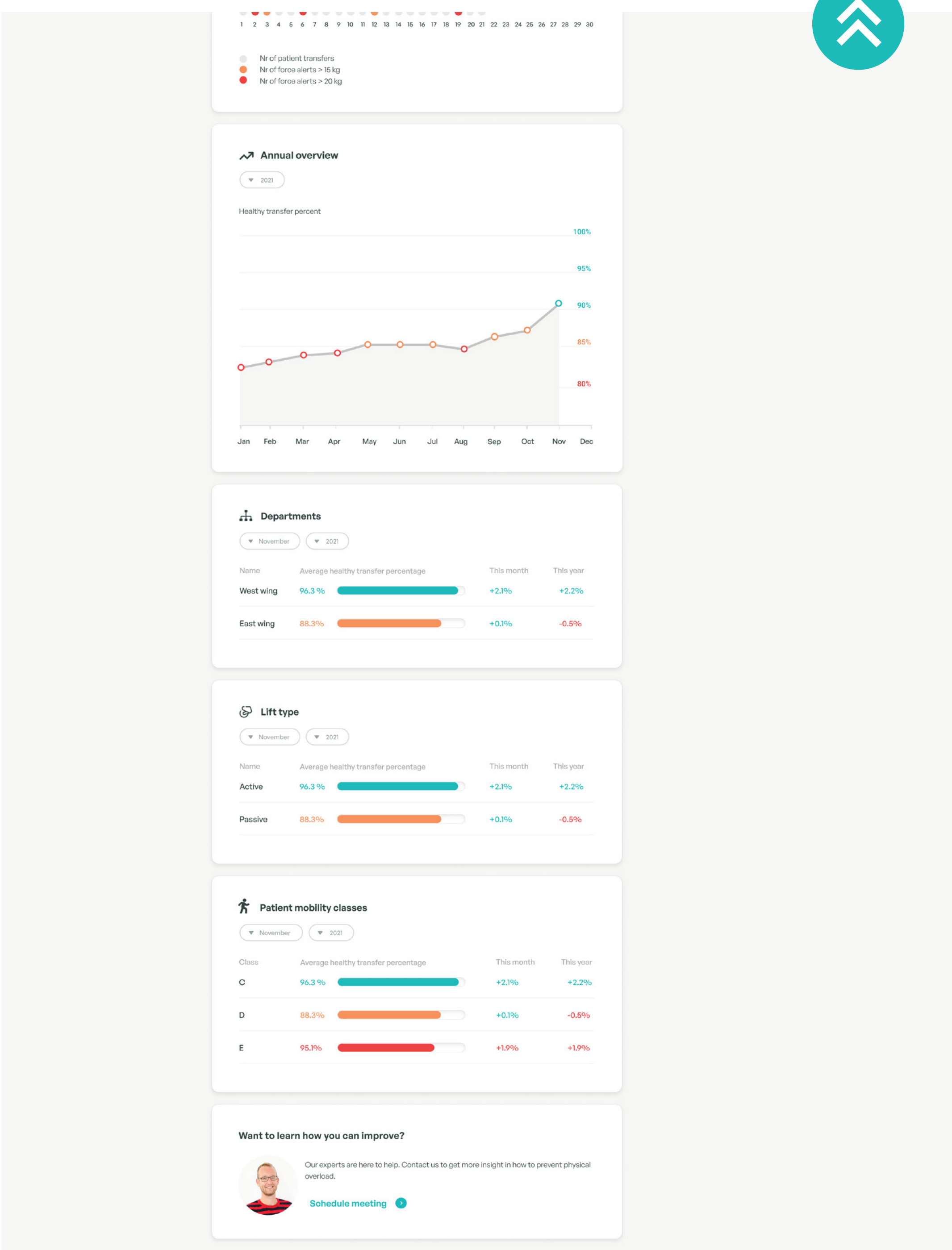
M2-A Future HWaaS Platform - 'My Location'



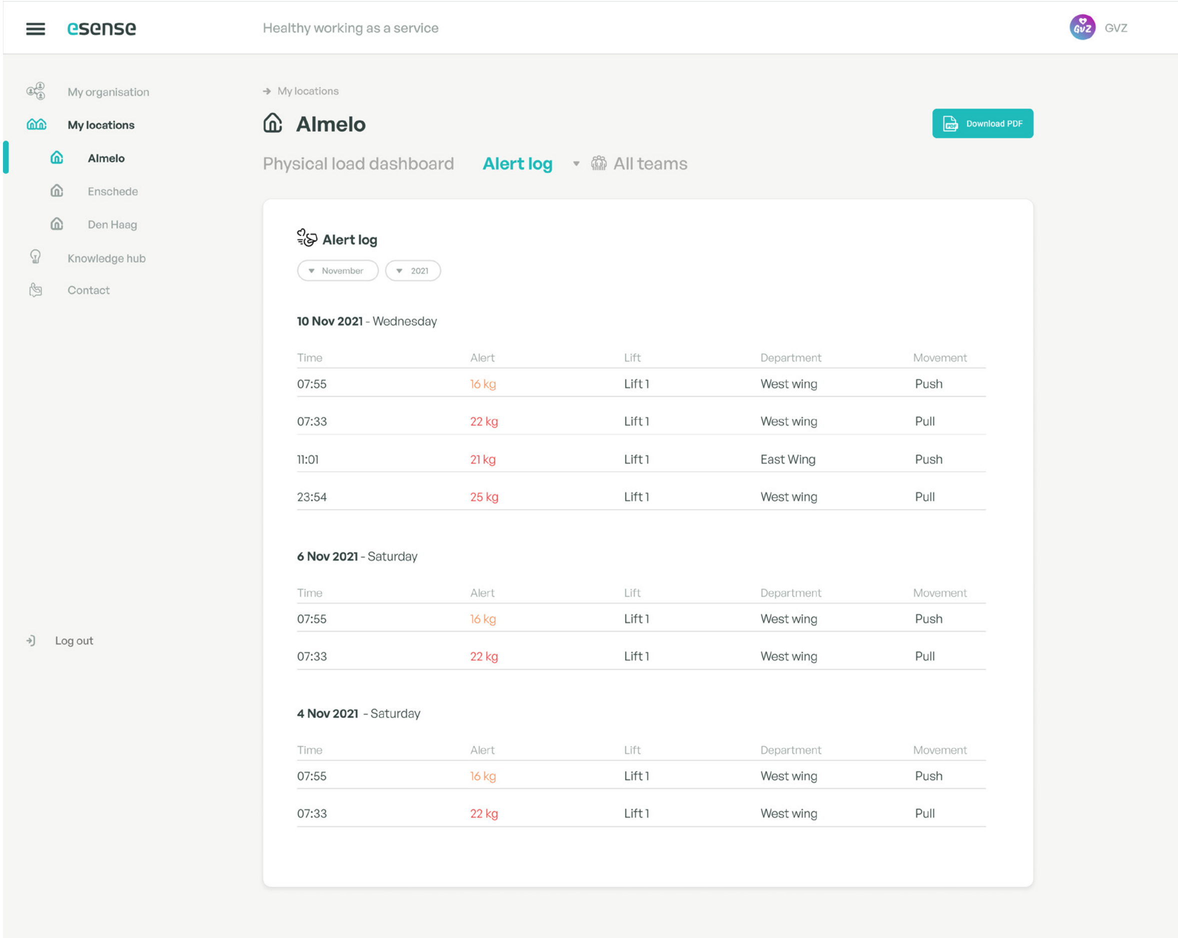
More on next page.

M2-B Future HWaaS Platform - ‘My Location’

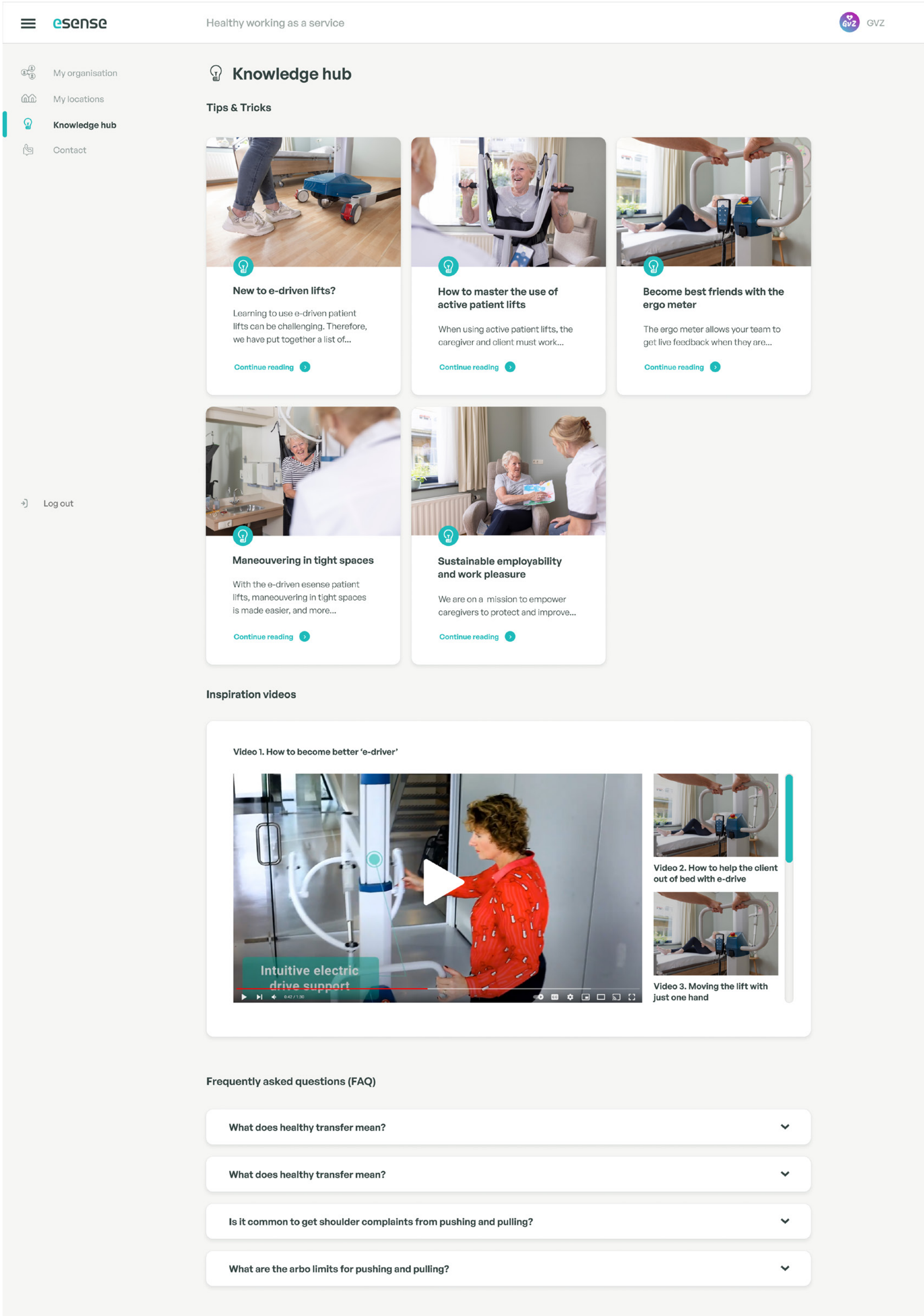
More on previous page.



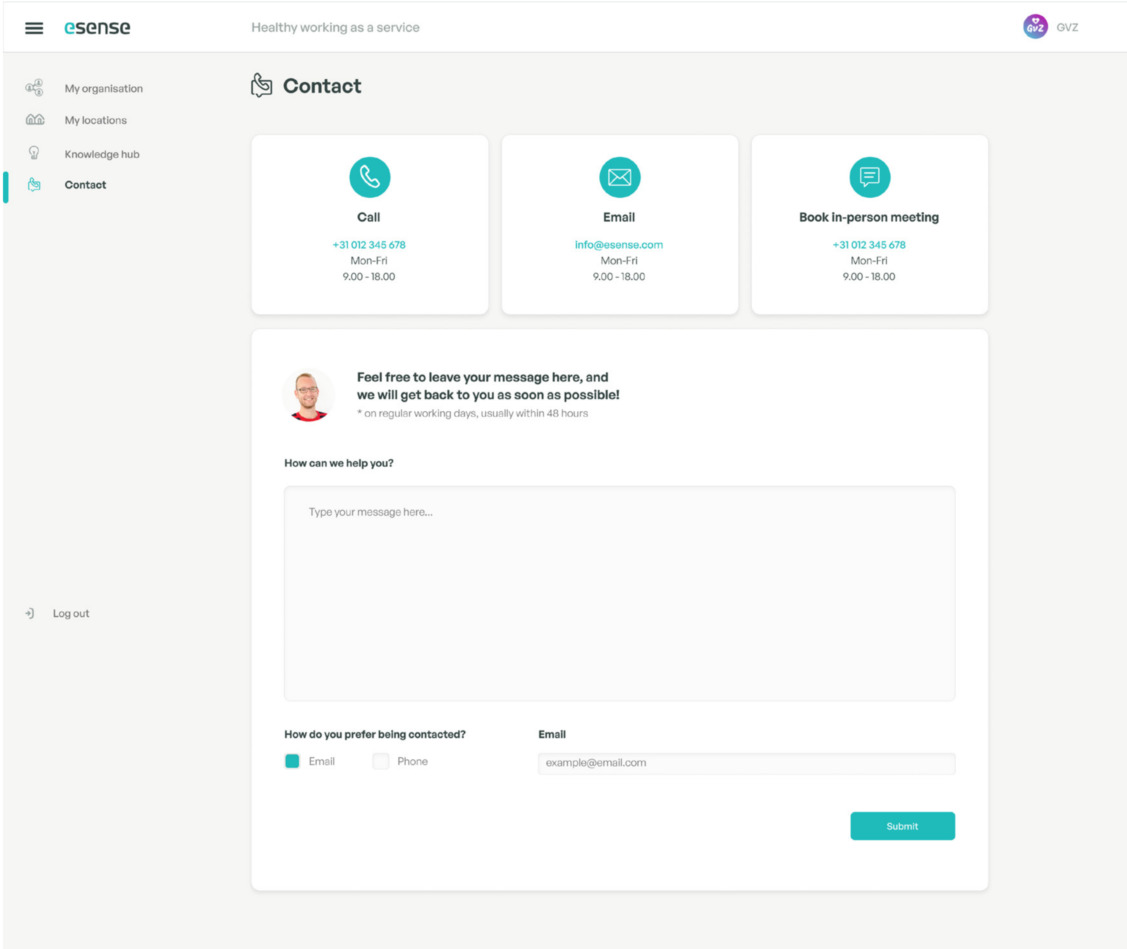
M3 Future HWaaS Platform - 'My Location' - Alert Log



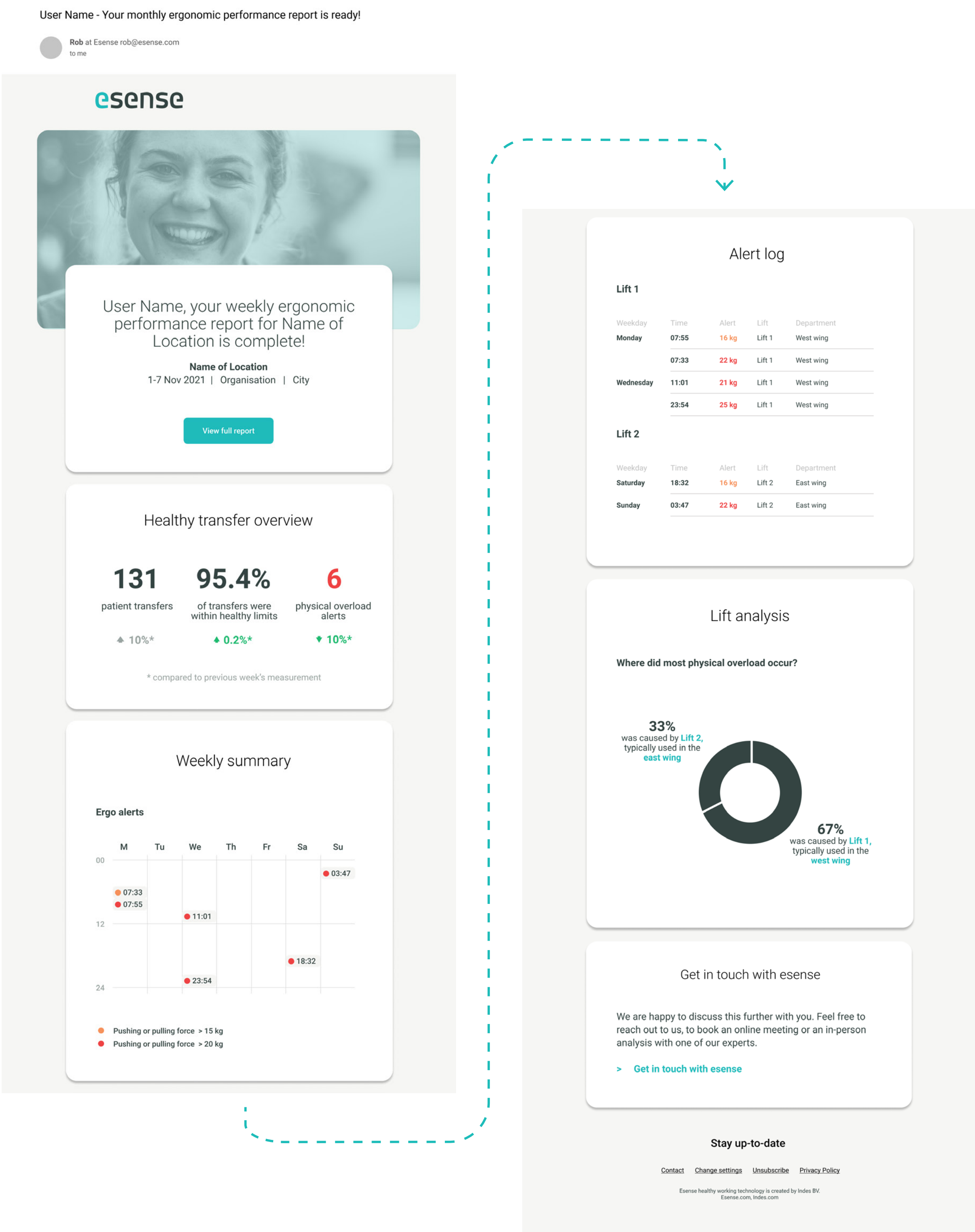
M4 Future HWaaS Platform - ‘Knowledge Hub’



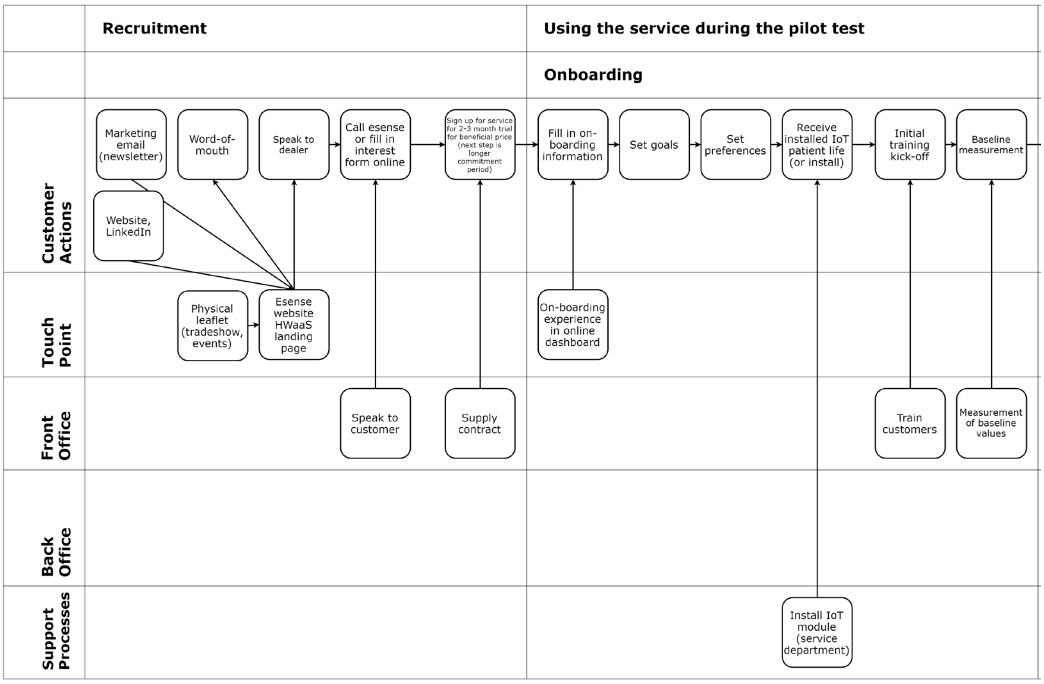
M5 Future HWaaS Platform - 'Contact Page'

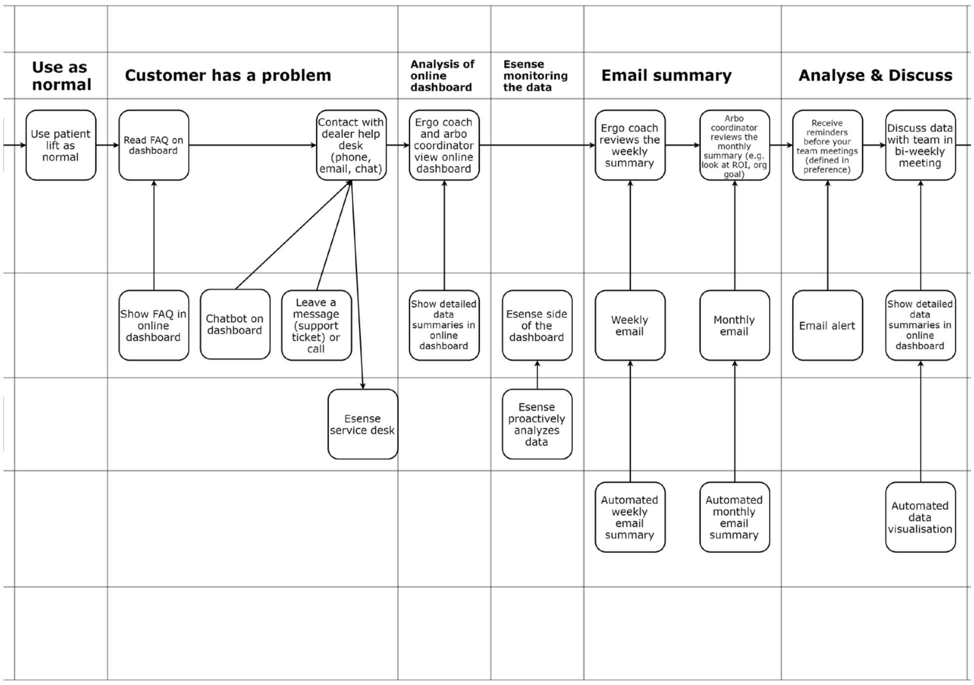


M6 Pilot Email Summary Report



M7-A Future Service Blueprint

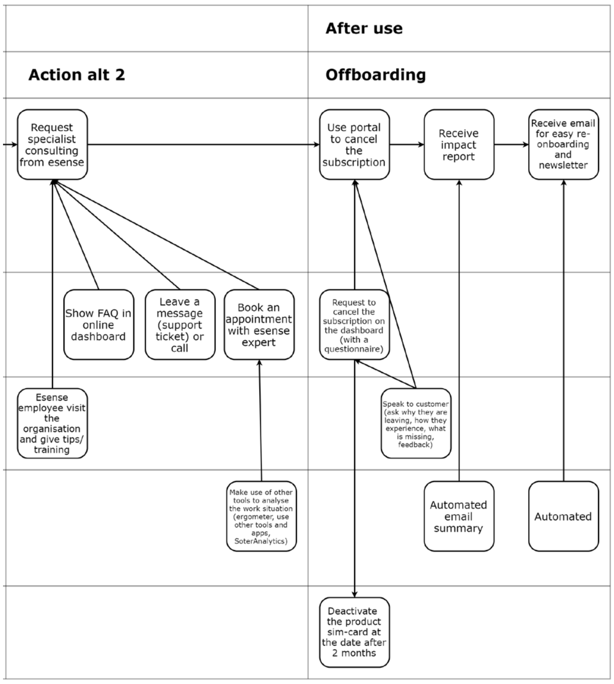




More on next page.

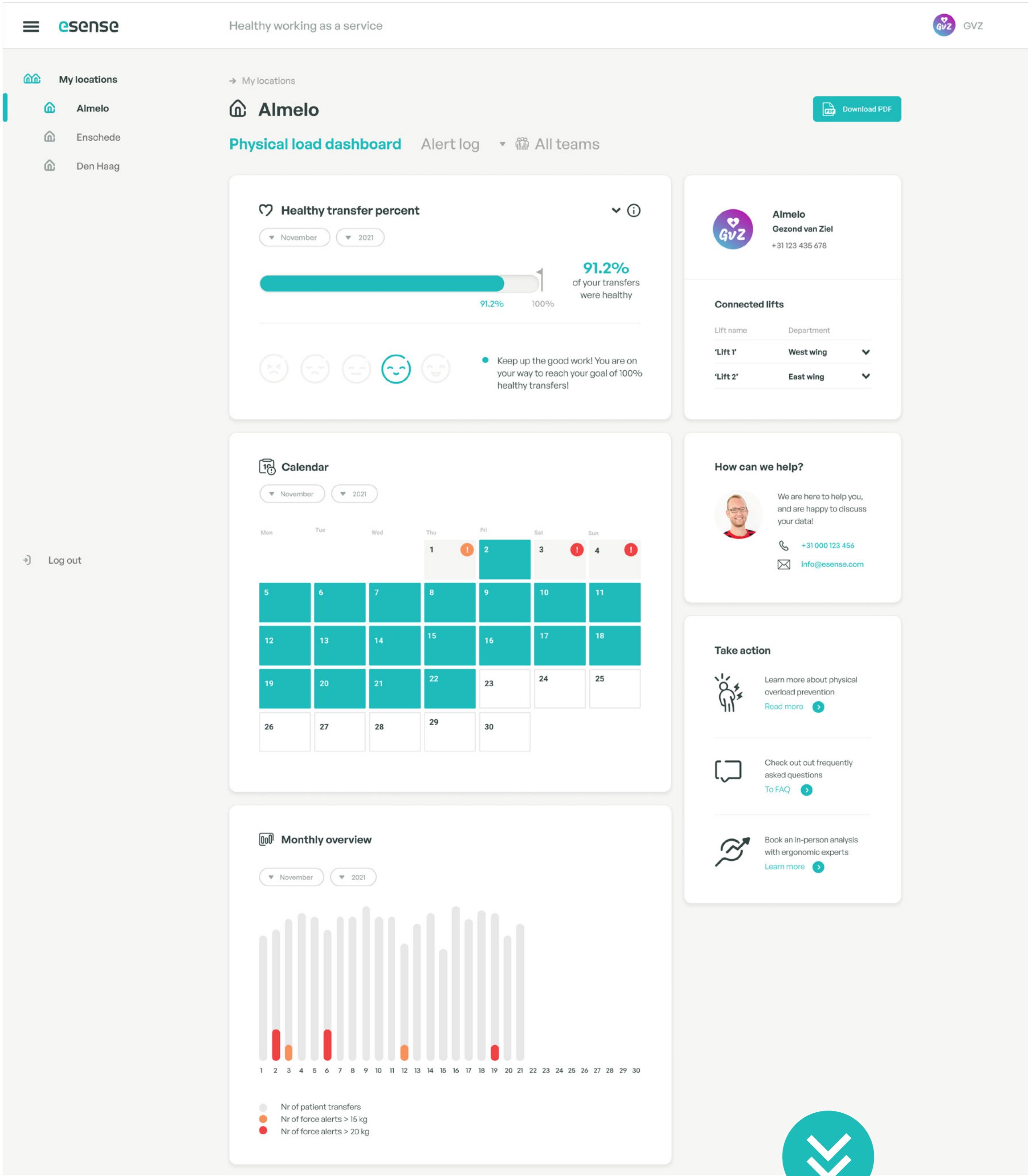
M7-B Future Service Blueprint

More on the previous page.



Appendix N

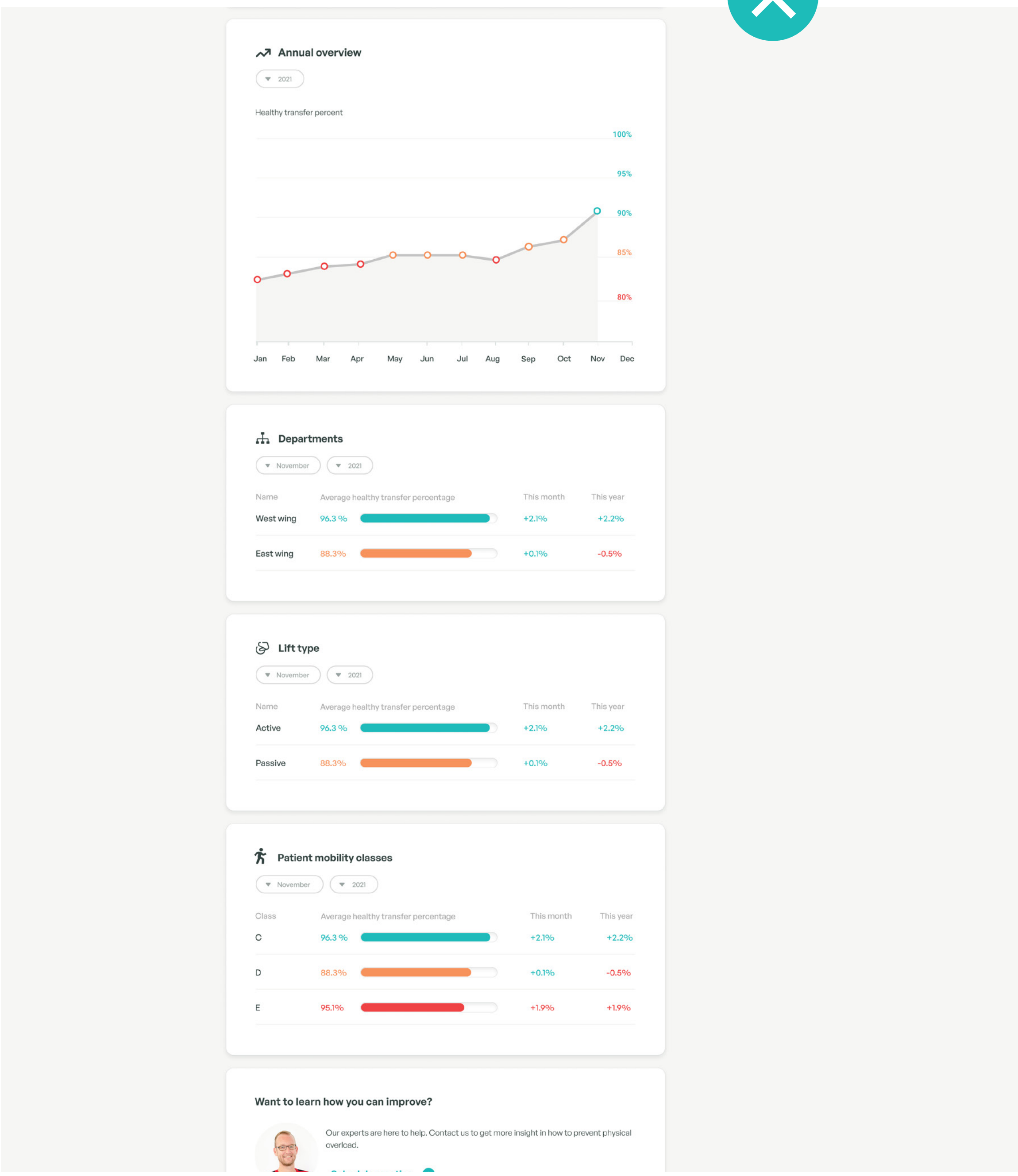
N1 Pilot Platform UI - My Location - Dashboard



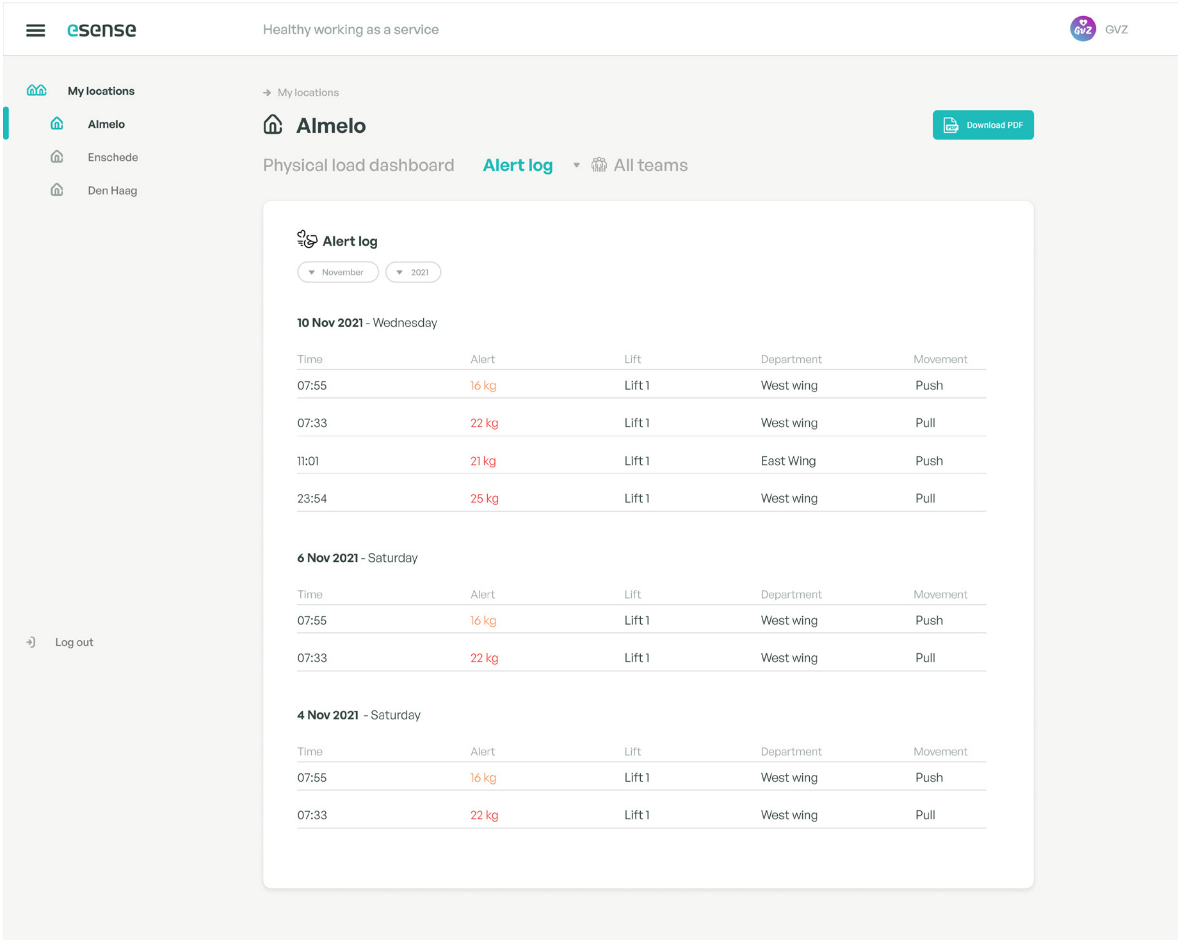
More on next page.

N2 Pilot Platform UI - My Location - Dashboard

More on the previous page.



N3 Pilot Platform UI - My Location - Alert Log



Appendix

01 Onboarding Questionnaire - Page 1

esense

Healthy working as a service

Onboarding

Welcome to the onboarding of the pilot test of Healthy working as a service! By filling in this form, you help us crate a service experience that is tailored to your unique circumstances. The data collected in this survey will not be shared with any external parties.

Do you have any questions? We are happy to help!

info@email.com

000 000 0000

O2 Onboarding Questionnaire - Page 2

1. Participant organisation information

Organisation name*

Location name*

Location address*

2. Pilot details

Starting date

End date

Nr of lifts in pilot

* = filled in by esense employees

O3 Onboarding Questionnaire - Page 3

3. Who can we contact?

Contact person 1

Name

Professional role

Email

Phone nr

Contact person 2

Name

Professional role

Email

Phone nr

—

* = filled in by esense employees

3

O4 Onboarding Questionnaire - Page 4

4. Tell us more about you!

Current practices

Do you currently have any way to measure physical overload?

How often did your team get patient lift training before COVID-19?

(It is okay to approximate)

Expectations & preferences

What are you hoping to learn from this experience?

Do you wish to receive the email summary weekly, or bi-weekly?

In what moments do you plan to discuss the data with your team?

* = filled in by esense employees

4

O5 Onboarding Questionnaire - Page 5

5. Lift 1

Unique product identifier *

Esense product type *

Is it an active or passive lift? *

From our initial research, we have found that in many healthcare locations, the patient lift is typically used by one team, in one department or on one floor. If this is also true for your location, please fill in this information.

Team

In which team is lift 1 typically used?

How many ergo coaches are in this team?

(It is okay to approximate)

Is your team experiencing any physical issues related to the patient transfer process?

(Not mandatory to answer)

Department

In which department, or on which floor, is this lift typically used?

What kind of floor is used in this department?

* = filled in by esense employees

5

06 Onboarding Questionnaire - Page 6

Are there any physical restrictions in this department that make manoeuvring a patient lift difficult?

Usage

How many different clients are transported with this lift?

(It is okay to approximate)

What mobility class do the clients transported with this lift belong to on average? (A-E)

(If not applicable, skip this question)

Thank you!

We are looking forward to collaborating with your organisation in this pilot test!

* = filled in by esense employees

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